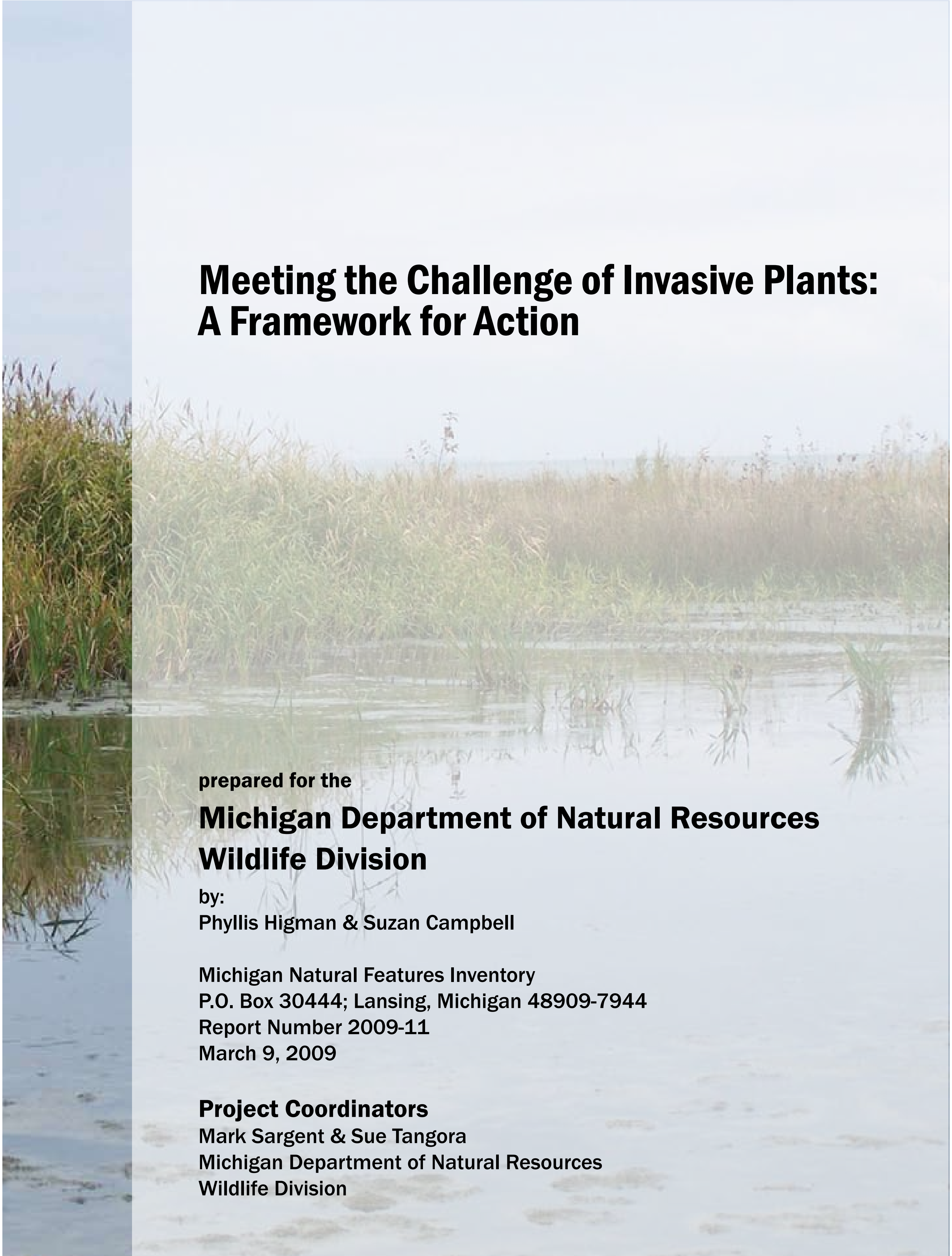
Meeting the Challenge of Invasive Plants: A Framework for Action



prepared for the

Michigan Department of Natural Resources Wildlife Division

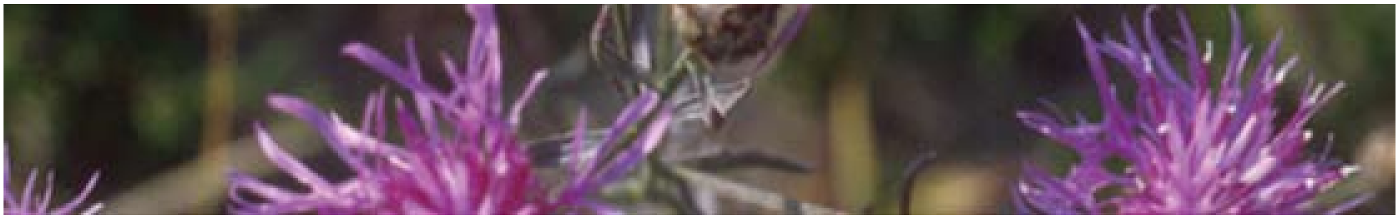
by:
Phyllis Higman & Suzan Campbell

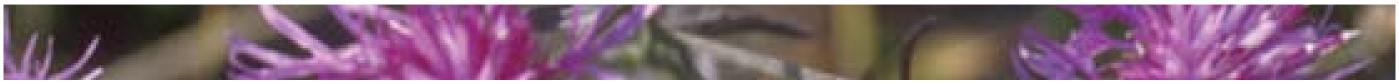
Michigan Natural Features Inventory
P.O. Box 30444; Lansing, Michigan 48909-7944

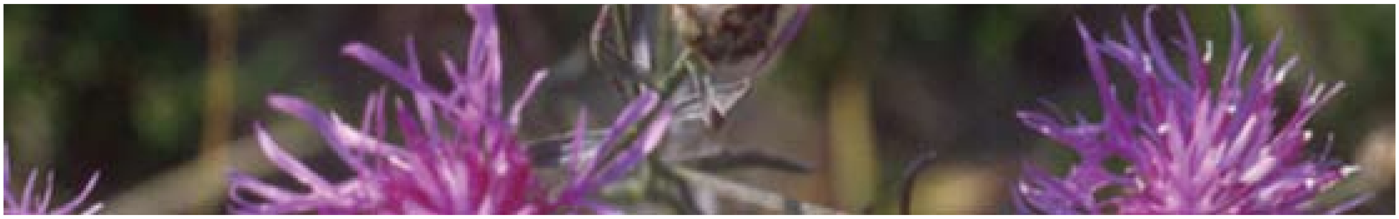
Report Number 2009-11
March 9, 2009

Project Coordinators

Mark Sargent & Sue Tangora
Michigan Department of Natural Resources
Wildlife Division







Acknowledgements

Support for this work was provided through a grant from the Michigan Department of Natural Resources, Wildlife Division. It was made possible by the determination of Project Coordinators, Mark Sargent and Suzan Tangora, to acknowledge and address the threat of invasive plants throughout Michigan. They saw the project through from start to finish and facilitated interaction with the Wildlife Division Management Team and Field Staff, and multiple partners. We greatly appreciate their leadership, guidance, support and expertise. Thanks also to Ray Rustem, who supported the project at its inception and provided valuable information regarding the Invasive Species Advisory Council and related legislation.

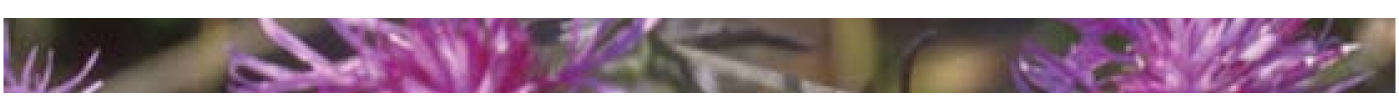
We thank the many Wildlife Division staff and regional stakeholders who attended meetings, provided data, and supported this work. Particular thanks to Wildlife Division staff Terry Minzey, Brian Mastenbrook, Sherry MacKinnon, Barb Avers, Ernie Kafkas, John Niewoonder, Michael Donovan, Brian Piccolo, Matt Edson, Doug Pavlovich, Jon Curtis, Julie Oaks, Steve Griffith, John Schafer, and Vern Stephens; USFS staff Ian Shackleford, Greg Schmidt, Sue Trull, Jan Schultz and Alix Cleveland; Greg Corace of the USFWS and Miles Falck of the Great Lakes Indian Fish and Wildlife Commission. They provided significant distribution or research data and assisted us with mapping protocols and field surveys. Our MNFI colleagues Edward Schools and Helen Enander developed a field mapping tool and Kim Borland gathered abundant information on many invasive plants.

The work of Kate Howe of the Midwest Invasive Plant Network, Doug Pearsall, Ellen Jaquert, and others from The Nature Conservancy, David Mindell of PlantWise, Bill Schneider of WildType Native Plant Nursery, Sherri Laier of the Michigan Nature Association, Glenn Palmgren and Bob Clancy from Parks Division and Kim Herman of FMFM was instrumental in shaping the strategic approach and identifying invasive plants of concern. We appreciate our partnership with Doug Landis, Amos Ziegler, Rob Ahern to develop the Michigan Invasive Species Information Network (MISIN) and to move invasive plant outreach and education forward in Michigan. Thanks to Tony Reznicek, Beverly Walters and others at the University of Michigan Herbarium for access to voucher information and their keen knowledge of species distribution and ecology.

We appreciate the strong support and expertise from Bob Heyd, Roger Mech, and Linda Lindberg from the Forest, Mineral and Fire Management Division, Lisa Brush of The Stewardship Network, Emily Finnell of the Michigan Department of Environmental Quality, and members of the Michigan and the Upper Peninsula Invasive Plant Council. Thanks also to our other colleagues at Michigan Natural Features Inventory for their overall support.

A special thank you to Ray Fahlsing, Dan Kennedy, Ryan O’Connor, Kerry Fitzpatrick, and Chris Hoving for reviewing drafts of this approach and providing valuable advice and support on all aspects of this project.

Finally to all of you listed here or not, who have supported and will continue to shape this work and move it steadily forward—thank you. We appreciate it greatly.



Contents

Executive Summary

Invasive plants have been identified as a serious threat to biodiversity globally. Once established, they out-compete native species, reducing diversity and altering ecosystem structure, composition, and function. The changes resulting from the most aggressive invasive plants are occurring rapidly enough that they pose a serious and costly threat to wildlife in Michigan.

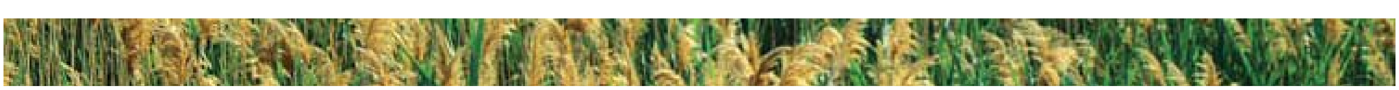
To address this concern, Michigan Department of Natural Resources (MDNR) Wildlife Division contracted with Michigan Natural Features Inventory (MNFI) to assess the status of invasive plants in Michigan and develop a strategy to address their negative impacts to wildlife. MNFI reviewed herbarium data and literature, participated in invasive species symposia, consulted with national, state, and local resource professionals, and conducted statewide field surveys to assess which species pose the greatest threat and where they occur. They also reviewed current invasive plant mitigation strategies to determine what actions have been most effective. Finally they held regional stakeholder meetings to gather input from staff and partners.

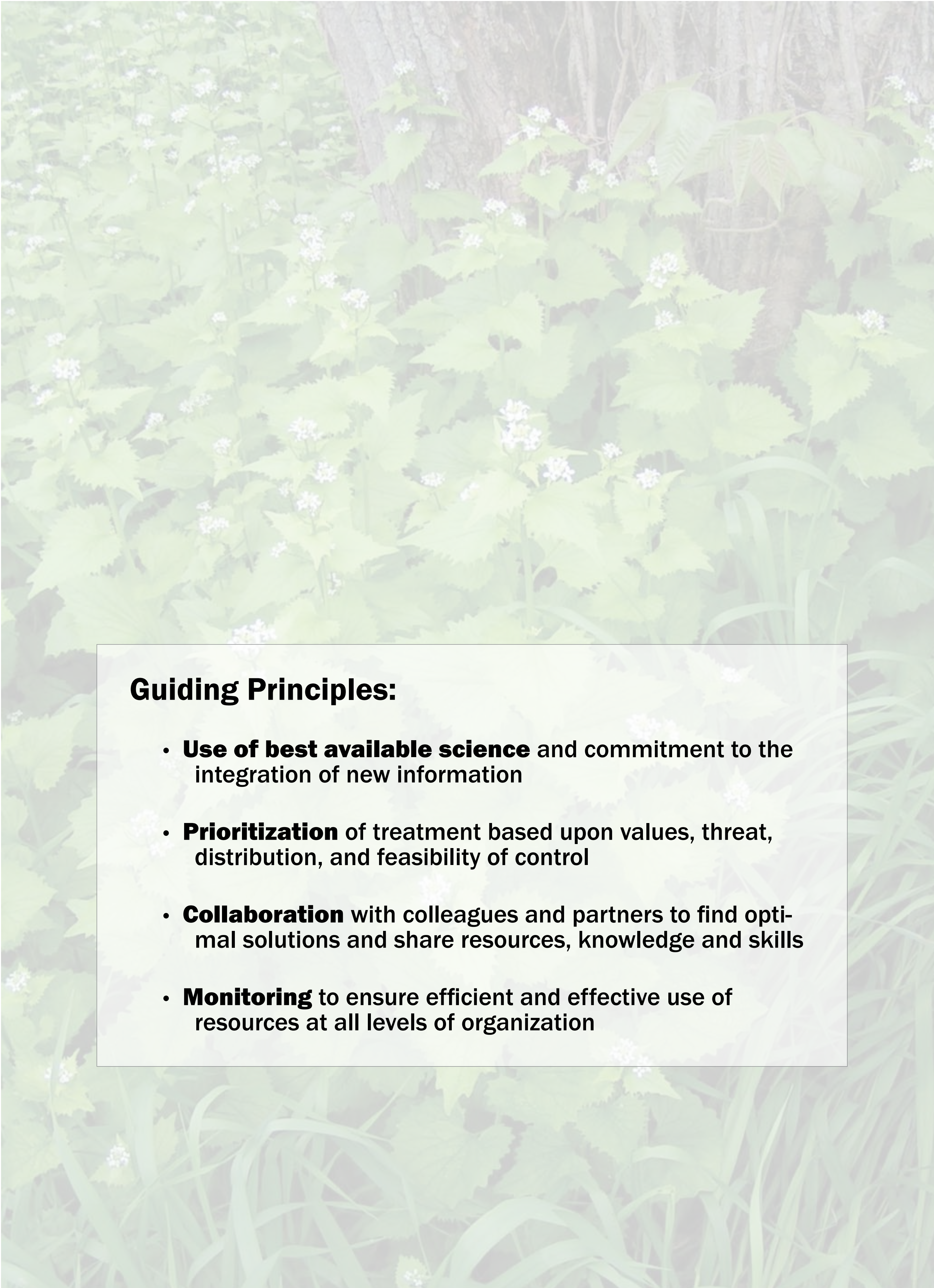
Numerous invasive plant species are well established in Michigan and spreading rapidly, however there is little current information on their distribution and abundance, and no official list of species that pose the greatest threat. Coarse scale surveys show that species of concern have colonized nearly every habitat type in Michigan and occur in every county of the state. There are many efforts underway to address their impacts, however there is little statewide coordination or cost-benefit analyses for action and no centralized source of information to help guide state, regional, and local efforts.

There is clear consensus that as invasive plant populations grow, the costs of treatment escalate, while the likelihood of successful mitigation declines. It is most cost effective to identify those species that pose the greatest threat to wildlife and direct actions towards prevention, early detection-rapid response, and control at prioritized sites. Using this tiered approach effectively requires an understanding of the most important places for supporting wildlife, the level of threat posed by the invader, the extent and abundance of the invader and effective control techniques and costs.

Six strategic goals and associated objectives were identified based upon the information gathered. The goals encompass a central framework of prevention, early detection-rapid response, and long-term control at strategically prioritized sites. They also include leadership to set direction and empower staff, assessment and research to help identify winnable battles, and education and outreach to improve and expand success. Four themes common to all the goals are presented as guiding principles. Preliminary lists of priority invasive species, sorted into recommended action categories are presented for Michigan's four major ecoregions to assist decision-making.

Goal one calls for the designation of a Wildlife Division invasive species coordinator and regional point staff to facilitate and coordinate action, assess progress, and set new priorities annually. Although this will require some resources and shifting of responsibilities, the approach presented is intended to maximize efficiency in the use of funds and staff time. Taking the time now to plan the pathway to success is important—the longer coordinated and decisive action is delayed, the higher the ecological and socio-economic costs to wildlife will be.





Guiding Principles:

- **Use of best available science** and commitment to the integration of new information
- **Prioritization** of treatment based upon values, threat, distribution, and feasibility of control
- **Collaboration** with colleagues and partners to find optimal solutions and share resources, knowledge and skills
- **Monitoring** to ensure efficient and effective use of resources at all levels of organization

Goals and Objectives

Goal 1: Leadership and Coordination—ensuring cost effective action

Facilitate the implementation of exemplary, science-based actions that eradicate or slow the establishment and spread of invasive plants that pose a threat to wildlife in Michigan.

objectives

- Designate an invasive plants coordinator and regional point staff.
- Pursue and secure funding to address invasive plants.
- Remove barriers to cross-jurisdictional action to facilitate rapid response and coordinated action.
- Influence state and regional policies that minimize the establishment and spread of invasive plants.
- Work with other states to gather and share information on the risk and spread of invasive plants.

Goal 2: Assessment and Research—the pathway to success

Assess the threat, status, and distribution of invasive plants that negatively impact wildlife.

objectives

- Develop and maintain lists of high threat invasive plants for targeted action.
- Establish centralized GIS-based database for mapping high-threat invasive plants.
- Improve distribution maps for high-threat invasive plant species.
- Use predictive modeling for high threat invasive plant species.
- Promote research on ecological and economi impacts to plant communities and wildlife, control practices and detection techniques for invasive plants

Goal 3: Prevention—the first line of defense

Prevent the introduction and establishment of high-threat invasive plants at state, regional, and local levels.

objectives

- Train staff on identification and best management practices.
- Identify and address entry points and pathways of spread.
- Adopt best management practices.
- Support policies and legislation that will minimize the impacts of invasive plants.

Goal 4: Early Detection and Rapid Response—the second line of defense

Enhance capacity to detect, report, and respond to newly detected introductions.

objectives

- Establish a reporting, verification, and alert system.
- Train staff and partners in early detection and rapid response.
- Develop rapid response and monitoring options for high-threat species.
- Establish response teams to conduct rapid assessment and treatment.
- Implement detection monitoring at strategic sites.

Goal 5: Control, Management, and Restoration—the third line of defense

Reduce the spread and harm caused by established invasive plants.

objectives

- Develop manual of control practices for treating invasive plants.
- Establish and implement processes for prioritizing action.
- Establish and implement protocols for documenting treatments and measures of success.
- Train staff to prioritize, implement and monitor treatments.
- Assess, implement and monitor prioritized treatments.
- Rehabilitate sites and restore key ecological processes where appropriate.

Goal 6: Education and Outreach—improving and expanding success

Provide educational opportunities and products to professional and public audiences

objectives

- Deliver educational events and products using multiple formats and media.
- Establish web site with information on invasive plants that pose a threat to wildlife.
- Share and gather information at professional meetings and conferences.
- Place information signs at high risk entry points and other strategic sites.
- Provide volunteer opportunities for mitigating invasive plant impacts.

I. Introduction

Invasive species are a serious threat to biodiversity globally; they are found in most wildlife habitats and know no borders. The National Invasive Species Council, established by Executive Order 13112 in 1999, defines invasive species as species that are:

> . . . non-native to the ecosystem under consideration, and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

The Wildlife Society's position statement on invasive plants and animals recognizes this threat, stating that "purposeful introductions should be assumed a risk until proven otherwise." The Society further opposes the degradation of natural biomes by invasive species and supports cost effective approaches to prevent their arrival and monitor their impacts. The Association of Fish and Wildlife Agencies, states that "at this point in time, the greatest single threat to wildlife of all kinds and sizes is the spread of exotic species, especially invasive plants." The Association asserts that invasive species present a clear threat to the "constituent elements of habitat quality" and that as public trust asset managers Wildlife Agencies should take a leadership role in mitigating their impacts.

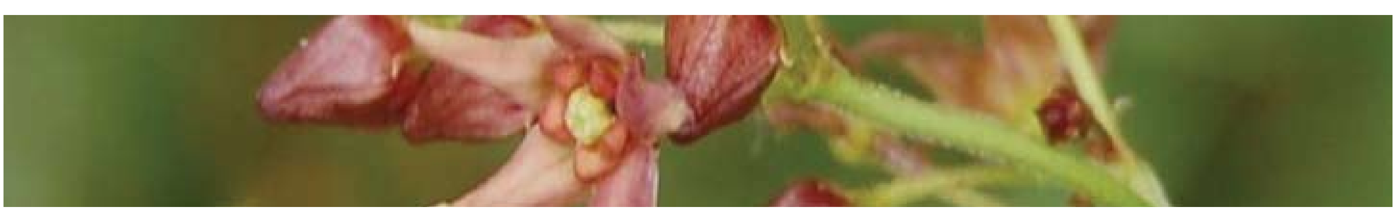
Hundreds of "non-native" species have been introduced to North America, either purposefully or by accident, through agricultural, horticultural, aquacultural and other trade, or stowed away in packing materials and ballast water. Also referred to as alien, exotic, or non-indigenous, these newcomers are for the most part useful and benign. However, some are very aggressive colonizers that once established, out-compete native species and alter ecosystem structure dramatically. Such species are considered "invasive." They disrupt complex interactions between native species that have evolved together over thousands of years, with consequences to wildlife. Many acres across North America and parts of Michigan have been reduced to cover types of predominantly invasive species and no longer support the same diversity of wildlife they once did. This homogenization of diverse ecosystems represents the harm to wildlife intended by the definition of invasive species. Where highly invasive plants have become established, valued ecosystems, species, including rare and declining wildlife, hunting opportunities and other wildlife related activities are diminished.

Invasive Species are:

"species that are non-native to the ecosystem under consideration, and whose introduction causes or is likely to cause economic or environmental harm or harm to human health"

National Invasive Species Council, 1999

As information on the negative impacts of invasive plants has grown, so have efforts to meet this challenge. The Ecological Society of America produced a report providing an overview of the threat of invasive species and recommending government actions focusing on prevention, responding rapidly to new infestations, and



controlling and limiting damage from existing invasions. An updated national plan identifying priority actions for 2008-2012 was completed in 2007 along with annual cross-cut budgets that coordinate national funding across recommended priority actions. The USDA National Forest Service, National Park Service, Natural Resources Conservation Service, US Fish and Wildlife Service and numerous other agencies and organizations are implementing strategic plans or initiatives to address negative impacts from invasive plants.

As a first and guiding principle, The Wildlife Society will promote the maintenance of biological diversity and ecosystem integrity and oppose the modification and degradation of natural biomes by invasive species.

The Wildlife Society Position Statement

As awareness has grown across the nation, invasive species have been increasingly considered in planning processes in Michigan. The Michigan Wildlife Action Plan has identified invasive species as one of two highest priority threats to wildlife in both aquatic and terrestrial systems. The MDNR State Forest Plan describes a desired future condition where state forests are protected from non-native invasive plants. Stakeholders listed invasive species as one of the seven future challenges for the MDNR, if not properly addressed today. Proposed new Forest Stewardship Council forest certification standards include the development and implementation of a strategy to prevent or control invasive species.

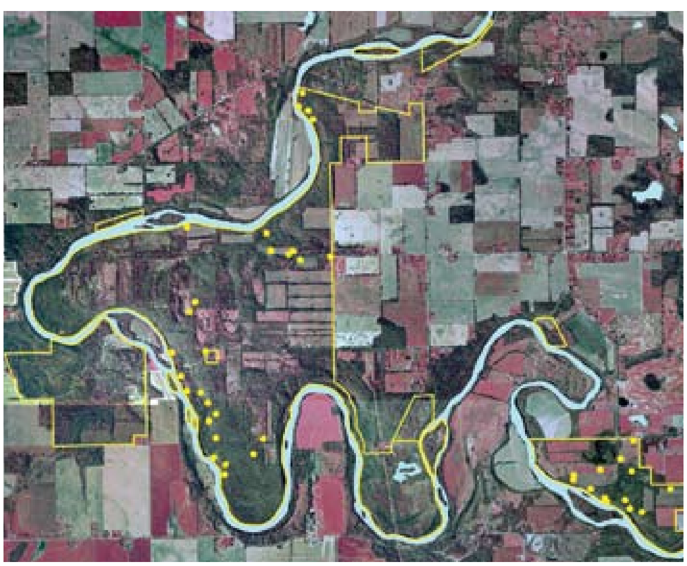
In light of these mandates, the MDNR Wildlife Division recognizes the need to clarify their role in mitigating the negative impacts of invasive plants on wildlife resources in Michigan. The Division spends hundreds of hours per year addressing invasive species, yet there is little guidance for engagement or common knowledge of species that pose the greatest threat or who is doing what where. This is in part because of the lack of a coordinated strategy and in part because of the lack of a public interface showcasing the work that is conducted. There is a need to focus and coordinate efforts within the Wildlife Division and with others, to shift the emphasis from reactive, high cost control, to proactive prevention and prioritization, and to publicize and share information derived from the work that is being conducted. This document provides a summary of the status of invasive plants in Michigan and presents a framework for action. The final section outlines four guiding principles and six strategic goals with associated objectives to help guide the Wildlife Division towards cost-effective mitigation of negative impacts of invasive plants on wildlife resources in Michigan.

The Michigan Wildlife Action Plan has identified invasive species as one of two highest priority threats to wildlife in both aquatic and terrestrial systems.

II. Assessment and Development of Strategy

The MDNR Wildlife Division contracted Michigan Natural Features Inventory to assess the status of invasive plants in Michigan and develop a strategy to address their negative impacts to wildlife. MNFI reviewed herbarium data and literature, consulted national, state, and local agencies and landowners, and attended conferences and symposia. They conducted field surveys to assess which species pose a threat to wildlife resources, where they are known to occur, what work is being conducted to address their impacts. The information gathered was used to identify key issues to explore further with Wildlife Division staff and partners. Ten topics were identified including the role of the Wildlife Division Management Team, prevention, early detection-rapid response, prioritizing efforts, monitoring, research, training, education and outreach, funding, and coordination.

The information gathered was used to identify key issues to explore further with Wildlife Division staff and partners. Ten topics were identified including the role of the Wildlife Division Management Team, prevention, early detection-rapid response, prioritizing efforts, monitoring, research, training, education and outreach, funding, and coordination.



Woody Invasive Species - Portland State Game Area

In March and April of 2008, four separate meetings were held in Marquette, Newberry, Roscommon, and Lansing to gather input from Wildlife Division staff, other MDNR Divisions, and interested partners such as The Nature Conservancy and other regional and local conservancies, the U.S. Fish and Wildlife Service, the Great Lakes Indian Fish and Wildlife Commission, and the Natural Resources Conservation Service. The intent of the meetings was to identify the level of staff knowledge, current efforts underway, issues that need to be addressed, and any other information that could inform the development of an effective set of strategic goals and objectives.

Each management unit and partner was provided an opportunity to describe how they were involved with invasive plants and to identify any difficulties or concerns they were having. The participants were then divided into groups, assigned two of the topics, and asked to conduct a one hour speed brainstorming process seeking to understand the topics and identify ways to address them. They were then given thirty minutes to prioritize the items they had listed, after which they reported out to the whole group. There was time for brief discussion among the participants after each topic was presented and then the meeting was adjourned.

Wildlife Division staff collectively have considerable knowledge of invasive species issues, the distribution of common invasive plant species within their region and typical control measures.

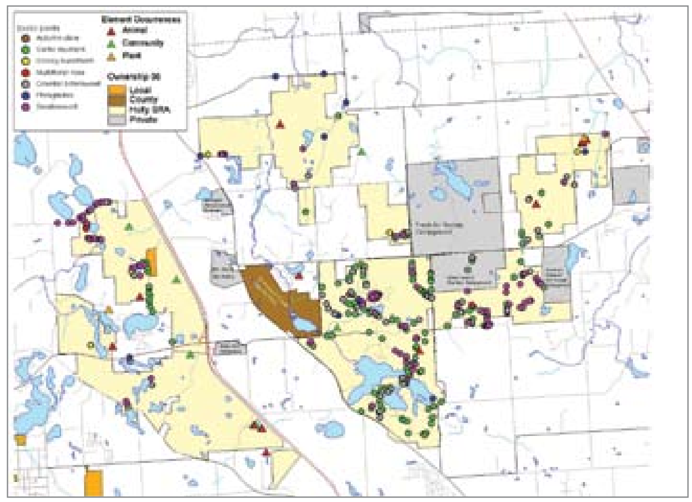
Twelve common themes emerged as priorities and are presented below. Similar priorities are reflected over and over again in the literature and in strategies and plans developed by other agencies.

- identification of roles and responsibilities and resources
- establishment of a reporting system for invasive plants
- identification of high threat species and better distribution maps
- establishment of early detection and rapid response teams
- identification and containment of currently known source infestations
- assessment and prioritization of control efforts
- coordination and collaboration with partners
- establishment and implementation of monitoring protocols
- better prevention methods, including sources of weed free mulch and other materials
- training in all facets of invasive plants, from identification to treatment monitoring protocols
- predictive modeling
- research documenting ecological economic impacts and best treatments

These priorities were used to guide the development of specific goals and objectives for the Wildlife Division. The goals and objectives were reviewed by a team of selected staff and partners and presented to the Wildlife Division Management Team for input. They were then revised by a wider audience. Final revisions were made and the document was sent to the Wildlife Division Management Team for approval.

The goals and objectives are presented in Section VII and the agenda and notes from these meetings were compiled and are provided in Appendix A.

The Southeast Wildlife Management Unit mapped a number of invasive plant species, tested several control techiques on each species and shared their results with other Wildlife Division staff and partners.



Assessing the extent and abundance of high-threat invasive plants is critical. If you don't know where the invasive plants are you are in the "ready, shoot, aim" mode. Take the time to aim first.

III. Impacts of Invasive Plants

While many people view native and non-native plants as interchangeable in the landscape, their habitat values are not necessarily equivalent. In the case of highly invasive species, which advance and dominate sites rapidly, this is cause for concern; diminished habitat quality has ecological, social and economic costs. Among their many impacts, invasive species may:

- Displace more valuable resources for wildlife;
- Not support critical components of the food chain, particularly invertebrates;
- Be unpalatable or toxic to wildlife;
- Disrupt mutualistic relationships between mycorrhizae and their plant hosts, which promote forest regeneration;
- Diminish the amount and quality of recreational opportunities, including hunting, hiking, bird-watching, etc.

Overall, the complex systems that characterize Michigan's wildlife habitats are simplified in lands dominated by invasive species; fewer species interact in simpler food webs and energy paths are less complex.

Social and economic costs are substantial also. It is impossible to hunt through a closed-in autumn olive stand, or to hunt woodcock in a glossy buckthorn thicket. "Huntable" marsh lost to *Phragmites* is no longer available to duck hunters, snipe hunters, etc. Loss of recreational opportunity translates into economic loss to local and state economies. The USFWS "2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation" noted that 753,000 hunters spent $915,884,000 in Michigan that year, and anglers spent another $1,454,182,000. The only other form of recreation documented in the report, "Wildlife watching," generated $1,622,521,000.

A short discussion of selected invasive species and issues follows, while an extensive annotated bibliography, covering a much wider range of invasive species and their impacts on wildlife, is included in Appendix D.

Phragmites has garnered widespread attention in the state's wetlands where dense impenetrable stands have displaced native vegetation, changing ecosystem structure dramatically. The most aggressive populations appear to be composed of plants with introduced Eurasian genotypes, although there are still stands of *Phragmites* with native genotypes persisting, even in southeast Michigan. Large scale efforts have been taken to control it in many areas including the St. Clair Flats, Beaver Island and Saginaw Bay. Typically, *Phragmites* replaces marsh, wet meadows, sedge/grass hummocks, wet prairie and other emergent wetlands.

In a recent study, specialized marsh birds including waterfowl, rails and swamp sparrows were significantly less abundant during the breeding season on *Phragmites*-dominated sites than in meadows or cattail marsh. Rails and soras occasionally nested along the edge of *Phragmites* stands but not in the interior. Some generalists such as red-winged blackbirds and marsh wrens, in contrast, appear to have benefited from *Phragmites*' expansion.

The myriad invertebrates . . . that are eaten by ducklings in their first few weeks of life, for example, are no longer abundant in the interior of *Phragmites*-dominated wetland.

Invasive species can change the diversity and relative abundance of insect prey that are eaten by wildlife including many birds, reptiles and amphibians. Charles Darwin first proposed the “enemy release” hypothesis in 1859, which states that non-native species have an advantage as they lack the “pests” of their native habitats. Ninety percent of insect herbivores are highly specialized, having evolved over thousands of years in response to the defenses of one or a few plant species. When non-native species are introduced, most native insects simply cannot eat them. Unfortunately, plant “pests” are also food for other animals, and this lack of insect herbivores on invasive species reduces their habitat value for native insectivorous species drastically.

The Eurasian genotype of *Phragmites* is eaten by 170 insect species in Europe but by only 26 species in North America and of those, only 5 are native. One species, reed scale, is eaten by birds, particularly the black-capped chickadee. *Phragmites* stands, however, displace a matrix of plant communities and open pools that support a wide range of invertebrates that are normally eaten by wildlife. The myriad invertebrates such as midge larvae, water boatmen, *Daphnia*, backswimmers, and snails that are eaten by ducklings in their first few weeks of life, for example, are no longer abundant in the interior of *Phragmites*-dominated wetland.

All changes to habitat from invasive species involve winners and losers; it is important that the resulting mix of plants and animals supports Wildlife Division’s management goals.

Approximately 96 percent of all terrestrial birds feed their young on insects, insect larvae and spiders and their relatives (which eat insects in turn). Recent studies suggest that the reduced availability of insect prey in habitat dominated by invasive plant species has a measurable affect on bird reproductive success. Researchers working with chipping sparrows found that grasshopper populations were significantly reduced on spotted knapweed (*Centaurea maculosa*) dominated sites in comparison with sites that were dominated by natives. The sparrows initiated nests later on knapweed-dominated sites, were less likely to double brood and also less likely to return to the same nest site in following years. They found that “declines in reproductive success and site fidelity were greater for yearling versus older birds and knapweed invasion appeared to exacerbate differences between age classes.”

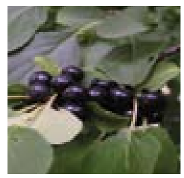


Photo: Brian Tang

While non-native shrubs produce berries that are eaten by birds, they are not palatable to most of the insects that birds need to successfully raise their young.

In another bird study, researchers compared the abundance and species richness of breeding birds, forb and grass species, and arthropods on rangeland sites dominated by native species and those dominated by two invasive exotic grasses. Arthropod abundance was 60 percent higher on native plant dominated sites and overall bird abundance was 32 percent higher on native grass dominated sites than on those dominated by exotic species. Birds that foraged on the ground underneath open brush canopies were almost twice as abundant on native grass sites.

Leafy spurge (*Euphorbia esula*) is a Eurasian forb that invades pastures, rangelands, prairies and barrens. All of its parts contain toxic milky latex, which is an irritant, emetic and purgative for many species. Unsurprisingly, they avoid it. Leafy spurge infestations reduce the carrying capacity of pastures for livestock by 50 to 75 percent but their impacts on wildlife are less well known. Western researchers have noted that leafy spurge significantly

reduced rangeland usage by bison, deer and elk. Deer use of spurge infested lands, for example, was up to 70 percent lower than that of uninfested lands. In 1979, leafy spurge was noted in 11 counties in Michigan and has since been documented in 41 counties. With a deep tap-root extending up to 15 feet long, it is extremely difficult to control. It is known to invade high quality grassland sites but its impacts on the state's wildlife populations or hunter experience have not been assessed.

Spotted knapweed invades similar habitats and is even more widespread in Michigan. In western Montana, when knapweed was removed from a historic elk winter range, elk use of the area increased dramatically.

Japanese knotweed (*Polygonum cuspidatum*) is an invasive species that is in 36 states including Michigan, where it is spreading. In its native range, its pests include 186 arthropod species along with approximately 50 species of pathogenic fungi. In the eastern U.S., even white-tailed deer will not eat it, although Japanese beetles will. Researchers in New York State compared green frog foraging success in knotweed colonies and non-invaded old field. No frogs in invaded areas gained weight, while most frogs gained weight in non-invaded areas.

Photo: Rich Thurman, USDA Forest Service

When spotted knapweed was removed from a historic elk winter range in western Montana, elk use of the area increased dramatically.

Mutualistic interactions involving invasive species have received little scrutiny until recently and researchers are just beginning to tease out critical relationships among organisms that are usually overlooked. Mycorrhizal fungi form mutualistic symbioses with about 2/3 of all plants. The fungi form nodules within or around the plant roots and provide critical nutrients and moisture to the plant while receiving carbon from it. Relationships between particular suites of fungi and their host are often species-specific. These relationships are particularly important for native trees, shrubs and some woodland wildflowers, which rely on them for growth and survival.

In healthy forests, the fungi form an extensive mycelial network. Some non-native invasive plants, including pale swallow-wort, privet and kudzu, are able to establish relationships with the more fast-growing, opportunistic fungi, which can lead to their spread at the expense of more conservative fungi and the natives that they benefit. In other cases, some invasive plants such as garlic mustard are non-mycorrhizal and may actually destroy the fungi. Garlic mustard whole-plant extracts contain a number of alleleopathic compounds with antifungal properties that are exuded through their roots and also by the plants as they decompose. Accordingly, at least part of their success is the result of their ability to suppress the regeneration of woody competitors, including canopy dominants.

Some Invasive plants can reproduce vegetatively by long underground stems (rhizomes) as shown in this photo of *Phragmites.* This species can even regenerate from fragments of the rhizome. It is difficult to dig it out successfully, because fragments often remain in the ground and grow into new plants.

A pocket field guide to invasive plants in Michigan will be available to MDNR field staff and partners.

IV. Current Status of Invasive Plants in Michigan

Species of Concern and their Distributions

There is no single official list of invasive plants posing the greatest threat to wildlife in Michigan. Sixteen aquatic invasive plant species are regulated under The Natural Resources and Environmental Protection Act 451, Part 413, Transgenic and Nonnative Organisms, and 51 species are regulated under the Michigan Department of Agriculture as noxious weeds. However these lists are far from adequate, particularly for terrestrial wildlife. They don't include many species that pose the greatest threat to wildlife, including woodland invaders such as garlic mustard, common buckthorn, or swallow-wort, or grassland invaders such as leafy spurge or spotted knapweed. Also, the noxious weed list includes many agricultural weeds that are not necessarily a high priority for action by the Wildlife Division.

There is also little detailed information available on the distribution of invasive plants throughout Michigan. Existing herbarium records were used to build baseline county distribution maps, highlighting the counties where they have been collected (Appendix B). These maps both over-represent and under-represent current distributions. Since there has been no systematic state-wide inventory and collection of invasive plants, many counties where they do occur are not reflected on the distribution maps. On the other hand, an entire county is shown as part of a plant's distribution, regardless of how widespread it is there. Numerous agencies and organizations are struggling to collect better distribution information as funding and priorities allow, but there is no standard method for data collection and no ability to aggregate these data statewide.

A statewide working list was created by contacting numerous agencies, conservancies, land managers, consultants, botanists, and others, reviewing the literature and web information across the Midwest, and compiling the results of targeted field surveys. This process revealed over 120 invasive plants of concern that are being monitored or actively managed to reduce negative impacts to wildlife and their habitats. The list is presented in Appendix C and indicates the ecosystems each species is known to invade, their general abundance and distribution in each of Michigan's four Regional Landscape Sections and any other special designations, such as restricted noxious weed. The categories used for general abundance and distribution include:

W: widespread

L: local occurrences

I: isolated occurrences

N: not present

		Wooded Upland	Open upland	Wooded Wetland	Open wetland	Aquatic	SLP	NLP	EUP	WUP	Section 324.41301	Federal Noxious Weed	MDA Noxious Weed
Scientific Name	**Common name**	**Habit**					**Region**				**Legal Status**		
Lysimachia nummularia	moneywort			■	■		I	N	N	I			
Lysimachia vulgaris	golden loosestrife				■		W	W	L	L			
Lythrum salicaria	purple loosestrife				■		W	W	W	W	R		
Marsilea quadrifolia	European water-clover					■	I	I	N	N			
Melilotus alba	white sweet clover		■				W	W	W	W			
Melilotus officinalis	yellow sweet clover		■				I	N	N	N			
Microstegium vimineum	Japanese stilt grass	■					I	N	N	N			
Morus alba	white mulberry	■	■				W	L	N	I			
Myriophyllum aquaticum	parrot feather					■	N	N	N	N	P		
Myriophyllum heterophyllum	variable-leaf watermilfoil					■	W	W	W	W			
Myriophyllum spicatum	Eurasian water milfoil					■	W	W	W	W	R		
Najas minor	lesser naiad					■	I	N	N	N			
Nasturtium officinale	watercress					■	W	W	W	W			
Nelumbo nucifera	sacred lotus					■	N	N	N	N			

While invasive species may seem overwhelming on some sites and in some regions, it is important to remember that they are not uniformly distributed throughout the state. For species that are just beginning to appear in Michigan, any efforts to control or eradicate them will confer benefits statewide. For species that are already established, it is important to remember that they can still be controlled or eradicated locally, where management values support this use of resources. For even the most widespread invasive plants, on some sites of high value, control efforts may be merited.

Invasive Plants in Michigan's Ecoregions

Southern Lower Michigan

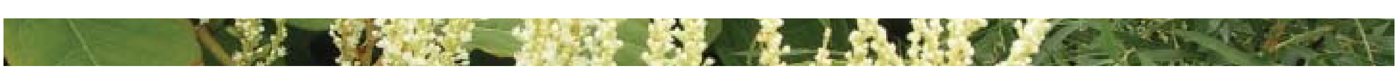
Michigan's Southern Lower Peninsula is particularly vulnerable to potential invaders as the most densely populated portion of the state. Widespread invasive plants include a number of species that were planted for landscaping or conservation including the Eurasian bush honeysuckles, common and glossy buckthorn, privet, barberry, multiflora rose, Oriental bittersweet, and autumn olive. Garlic mustard, spotted knapweed and *Phragmites* are also widespread. Eradicating these species is not a realistic goal, but there are many sites where they can be eliminated or managed locally. Emerging threats such as black and pale swallow-wort and Japanese and giant knotweed are particularly important targets; successes in eradicating or controlling their spread in this region will have cascading benefits statewide. Jetbead, an ornamental shrub, appears to pose a lower threat but could probably still be eradicated. In Southeast Michigan, European frog-bit is spreading steadily from Lake St. Clair down to Lake Erie and water hyacinth appears to be overwintering successfully in small numbers during some years, in spite of its sensitivity to cold. Flowering rush, which has been present for many years, is now expanding rapidly, entering inland lakes, as well as coastal areas. In Southwestern Michigan, Dalmation toadflax and Lyme-grass are cropping up in dunes and other sandy areas. The western side of the state is also vulnerable to aquatic species entering via Lake Michigan, including *Hydrilla* which has been found in Indiana and Wisconsin but appears to have been contained. It is not clear whether or not Japanese stilt grass has entered Michigan yet but it is found just south of the state and should be eradicated when it appears.

Northern Lower Michigan

The Northern Lower Peninsula contains many of the same invasive species as the Southern Lower Peninsula, including garlic mustard and many of the shrubs. They are found in fewer locations on state lands and could likely be controlled or potentially eradicated in many places. Glossy and common buckthorn are locally abundant in many locations, acting as source populations for further spread. Japanese knotweed, giant knotweed, Oriental bittersweet, flowering rush and the swallow-worts are all prime candidates for early detection-rapid response efforts. *Phragmites* is still relatively local and aggressive control efforts are warranted. Some species, like spotted knapweed, are already widespread. European swamp thistle, leafy spurge and wild parsnip appear to be entering the area from the Upper Peninsula and are clearly moving along roadways. On the western side of the state, efforts are underway to eradicate baby's breath, which has invaded dune areas. Lyme grass is receiving early detection attention in the dunes as well.

Eastern Upper Peninsula

Aquatic and wetland species appear to be moving into the Eastern Upper Peninsula more rapidly than upland species, which is not surprising given its relative terrestrial isolation. *Phragmites*, European swamp thistle, curly pondweed and Eurasian milfoil occur in a number of counties and flowering rush is found around the Straits. It is important to note that native *Phragmites* is common along coastal and inland wetlands and care should be taken to confirm the identification of any *Phragmites* occurrences thought to be non-native in the region. Scotch pine has become a nuisance for forest management and attempts to eradicate it are underway in many locations. Major infestations of glossy buckthorn are found at Seney National Wildlife Refuge and along an approximately 7 mile stretch of US-2 emanating east and southwest of Escanaba. Successful containment efforts have been on-going for a number of years at Seney. Large infestations of garlic mustard have been treated at the Cut-River Bridge and in hardwoods north of Epoufette, also showing some success. Aggressive monitoring and containment of these known infestations should be a high priority. Aside from these infestations, garlic mustard and glossy buckthorn are less common in this region, as are many of the other invasive shrubs—all warrant aggressive early detection-rapid response efforts. Populations on private lands should be considered in this process. Wild parsley and leafy spurge are locally widespread and are abundant along major roadways. Strategic efforts to control dispersal corridors, detect and respond to new in-



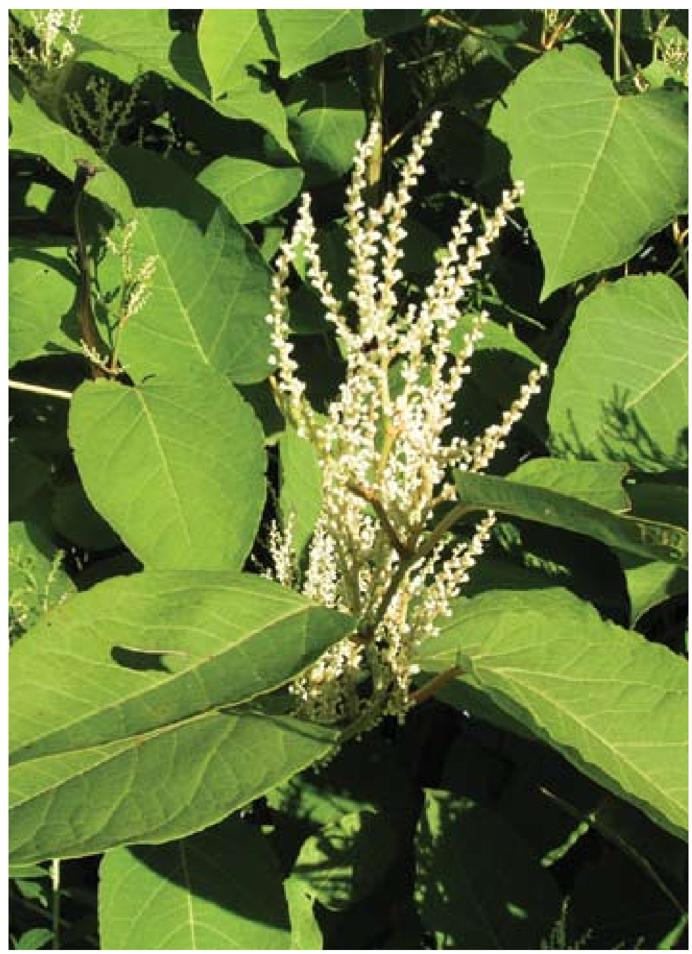
vasions in off-corridor sites or implement treatment locally to meet management goals are recommended. Spotted knapweed is widespread in the region and has invaded many important sites including Bullock ranch, a sharp-tail grouse breeding site, and the Maxton Plains Natural Area on Drummond Island which harbors a number of rare species in the state. Considerable thought should be given to prioritizing if and where control efforts should be undertaken for this species. Biological control is on the horizon for this species and control agents have been introduced several at sites in the state.

Western Upper Peninsula

The Western Upper Peninsula generally appears to have more occurrences of upland invasive plants than the Eastern Upper Peninsula, including common buckthorn, barberry, honeysuckle, Japanese and giant knotweed, autumn olive and black locust which are locally common in some areas. Though most are not widespread on state lands, a major source population of common buckthorn occurs near Alpha in Iron County and glossy buckthorn is radiating outward along the Iron River near Caspian. Garlic mustard is known primarily from the Munising area and around Marquette. Baby's breath and giant hogweed appear to be just entering the area and are appropriate early detection-rapid response targets. Eurasian swamp thistle, leafy spurge and wild parsnip are locally abundant and spreading along major roadways. Curly pondweed and Eurasian milfoil have been found in this area, but are not yet represented in herbarium records. *Phragmites* is still isolated, but similar to the Eastern Upper Peninsula, care should be taken to distinguish native from non-native occurrences. Flowering rush has not been reported but is present just over the Wisconsin border.

General Considerations for Tracking Invasive Plants

In assessing the status and movement of invasive plants in various regions of the state, it is useful to consider potential pathways and dispersal modes for the spread of both new invaders and those that have been here for a while. For aquatic invaders, initial introductions were historically associated with the shipping industry and tended to first appear in southeastern Michigan. Once established, however, their movement within the state and region has occurred by leaps and bounds as recreational boaters transport plants between lakes. Clean boating programs and other educational efforts have reduced the rate of introduction but have not eliminated it completely. For species with bird-dispersed fruit such as buckthorn or honeysuckle, which were planted widely for many years, invasion emanates from populated areas steadily along a broad front. For still other species such as garlic mustard, in which seed falls near the parent plant, movement of seed-infested soil is facilitated across short distances by animals and longer distances by hikers, vehicles and maintenance crews. Similar modes of dispersal operate for species such as *Phragmites* and Japanese knotweed that can regenerate from root fragments. Fragments for these species can be dispersed by water courses as well.



Regional Invasive Plant Lists

Short lists of priority species for action have been identified for each of Michigan's four major ecoregions by sorting the statewide working list based upon currently known distributions and anticipated threat. The current distribution and level of threat for each species was gauged by preliminary results of formal risk assessments by the Michigan Invasive Plant Council, other national and regional risk assessments, information from land managers across the state, and targeted coarse level field surveys conducted throughout Michigan, primarily on state lands. The lists differ for each region because of the differing ranges of individual species and their currently known distribution and abundance in the state.

The species are grouped into four categories of recommended action are based on several assumptions:

- it is more cost effective to address species before they are well established
- species posing a higher threat generally should be a higher priority for treatment
- treatments should be prioritized where success is likely
- it sometimes is advantageous to treat species posing any level of threat where resources permit.

Action categories

A list species:
Medium to high threat; mostly isolated occurrences, treat wherever found.

B list species:
Medium to high threat; mostly local—found in some areas but not others; designate areas for eradication, suppression or containment; may choose to control based on specific management goals and situations.

C list species:
Medium to high threat; widespread; no action required; may choose to control based on specific management goals and situations.

D list species:
More information required; may choose to control based on specific management goals and situations.

Formal weed assessments in Michigan consider:

- Reproduction and dispersal
- Impacts
- Distribution
- Known control methods
- Control efforts on-going
- Value within the State of Michigan.

The short lists of species and recommended action categories are presented as an initial starting point to focus effort. However, all species on the statewide working list pose a potential threat to Michigan's wildlife and new species will continue to arrive. It is fully expected that as managers become more familiar with species of concern and treatment options, these lists will evolve over time to better address the highest priority threats. The lists and recommended actions serve as guidelines only; decision-makers must take local management priorities, site conditions, and expertise into account. They should be reviewed and updated regularly based upon on-going risk assessments and new information as populations disperse and are treated across the state.

Southern Lower Peninsula

A List Species	
Amur cork-tree	*Phellodendron amurense*
black jetbead	*Rhodotypos scandens*
European frog-bit	*Hydrocharis morsus-ranae*
giant hogweed	*Heracleum mantegazzianum*
giant knotweed	*Polygonum sachalinensis*
Hydrilla	*Hydrilla verticillata*
Japanese stilt grass	*Microstegium vimineum*
kudzu	*Pueraria lobata*
Norway maple	*Acer platanoides*
pale swallowwort	*Vincetoxicum rossicum*
black swallowwort	*Vincetoxicum nigrum*
reed mannagrass	*Glyceria maxima*
water-hyacinth	*Eichhornia crassipes*

B List Species	
baby's breath	*Gypsophila paniculatus*
flowering rush	*Butomus umbellatus*
Japanese knotweed	*Polygonum cuspidatum*
leafy spurge	*Euphorbia esula*
Russian olive	*Elaeagnus angustifolia*
Scotch pine	*Pinus sylvestris*

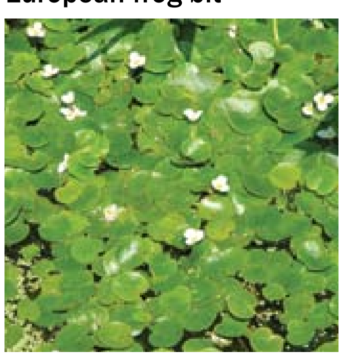
C List Species	
Amur honeysuckle	*Lonicera maackii*
autumn olive	*Elaeagnus umbellata*
Japanese barberry	*Berberis thunbergii*

C List Species - continued	
Bell's honeysuckle	*Lonicera Xbella*
black locust	*Robinia pseudoacacia*
Canada thistle	*Cirsium arvense*
common buckthorn	*Rhamnus cathartica*
curly pondweed	*Potamogeton crispus*
Eurasian water milfoil	*Myriophyllum spicatum*
European fly honeysuckle	*Lonicera xylosteum*
garlic mustard	*Alliaria petiolota*
glossy buckthorn	*Rhamnus frangula*
Japanese honeysuckle	*Lonicera japonica*
Morrow's honeysuckle	*Lonicera morrowii*
multiflora rose	*Rosa multiflora*
Oriental bittersweet	*Celastrus orbiculata*
purple loosestrife	*Lythrum salicaria*
reed canary grass	*Phalaris arundinacea*
Phragmites	*Phragmites australis*
Scotch pine	*Pinus sylvestris*
spotted knapweed	*Centaurea maculosa*
Tartarian honeysuckle	*Lonicera tatarica*
tree-of-heaven	*Ailanthus altissima*
variable-leaf watermilfoil	*Myriophyllum heterophyllum*

D List Species	
black alder	*Alnus glutinosa*
European highbush cranberry	*Viburnum opulus*
lesser naiad	*Najas minor*

Black swallow-wort

European frog-bit



Japanese stiltgrass

Hydrilla

Northern Lower Peninsula

A List Species	
Amur honeysuckle	*Lonicera maackii*
black jetbead	*Rhodotypos scandens*
black swallowwort	*Vincetoxicum nigrum*
common buckthorn	*Rhamnus cathartica*
European frog-bit	*Hydrocharis morsus-ranae*
flowering rush	*Butomus umbellatus*
garlic mustard	*Alliaria petiolota*
giant hogweed	*Heracleum mantegazzianum*
giant knotweed	*Polygonum sachalinensis*
Japanese barberry	*Berberis thunbergii*
Japanese knotweed	*Polygonum cuspidatum*
Japanese stilt grass	*Microstegium vimineum*
leafy spurge	*Euphorbia esula*
multiflora rose	*Rosa multiflora*
Norway maple	*Acer platanoides*
Oriental bittersweet	*Celastrus orbiculata*
pale swallowwort	*Vincetoxicum rossicum*
Phragmites	*Phrgmites australis*
privet	*Ligustrum obtusifolium*
reed mannagrass	*Glyceria maxima*
Russian olive	*Elaeagnus angustifolia*
swamp thistle	*Cirsium palustre*
tree-of-heaven	*Ailanthus altissima*
wild parsnip	*Pastinaca sativa*

B List Species	
autumn olive	*Elaeagnus umbellata*
baby's breath	*Gypsophila paniculatus*
Bell's honeysuckle	*Lonicera* Xbella
black locust	*Robinia pseudoacacia*
Canada thistle	*Cirsium arvense*
glossy buckthorn	*Rhamnus frangula*
Morrow's honeysuckle	*Lonicera morrowii*
reed grass	*Phragmites australis*
Scotch pine	*Pinus sylvestris*
Tartarian honeysuckle	*Lonicera tatarica*

C List Species	
common St. John's-wort	*Hypericum perforatum*
curly pondweed	*Potamogeton crispus*
Eurasian watermilifoil	*Myriophyllum spicatum*
reed canary grass	*Phalaris arundinacea*
spotted knapweed	*Centaurea maculosa*
variable-leaf watermilfoil	*Myriophyllum heterophyllum*

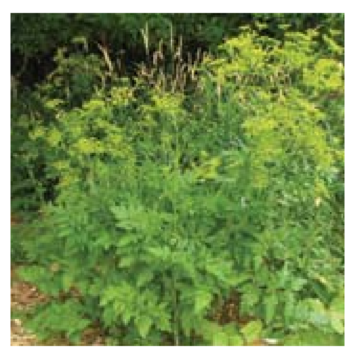
D List Species	
European highbush cranberry	*Viburnum opulus*
European water-clover	*Marsilea quadrifolia*
Japanese hedge-parsley	*Torilis japonica*
money-wort	*Lysimachia nummularia*
purple loosestrife	*Lythrum salicaria*

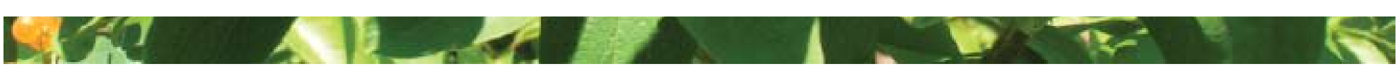
Japanese knotweed

Oriental bittersweet

Pale swallow-wort

Wild parsnip





Eastern Upper Peninsula

A List Species

baby's breath	*Gypsophila paniculata*
black locust	*Robinia pseudoacacia*
common buckthorn	*Rhamnus cathartica*
garlic mustard	*Alliaria petiolota*
giant knotweed	*Polygonum sachalinensis*
glossy buckthorn	*Rhamnus frangula*
Japanese barberry	*Berberis thunbergii*
Japanese knotweed	*Polygonum cuspidatum*
leafy spurge	*Euphorbia esula*
multiflora rose	*Rosa multiflora*
Norway maple	*Acer platanoides*
privet	*Ligustrum obtusifolium*
purple loosestrife	*Lythrum salicaria*
Phragmites	*Phragmites australis*
wild parsnip	*Pastinace sativa*

B List Species

Amur honeysuckle	*Lonicera maackii*
autumn olive	*Elaeagnus umbellata*
European fly honeysuckle	*Lonicera xylosteum*
Morrow's honeysuckle	*Lonicera morrowii*
Scotch pine	*Pinus sylvestris*
swamp thistle	*Cirsium palustre*
Tartarian honeysuckle	*Lonicera tatarica*

C List Species

Canada thistle	*Cirsium arvense*
common St. John's-wort	*Hypericum perforatum*
curly pondweed	*Potamogeton crispus*
Eurasian water milfoil	*Myriophyllum spicatum*
reed canary grass	*Phalaris arundinacea*
spotted knapweed	*Centaurea maculosa*
variable-leaf watermilfoil	*Myriophyllum heterophyllum*

D List Species

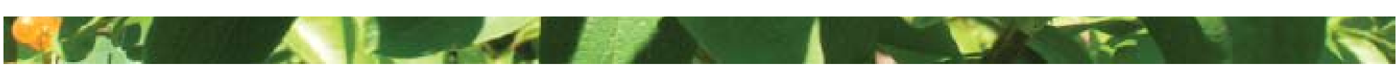
Japanese hedge-parsley	*Torillis japonica*
European highbush cranberry	*Viburnum opulus*
moneywort	*Lysimachia nummularia*

Curly pondweed

Scotch pine

Glossy buckthorn

Leafy spurge



Western Upper Peninsula

A List Species

Amur honeysuckle	*Lonicera maackii*
baby's breath	*Gypsophila paniculata*
black locust	*Robinia pseudoacacia*
common buckthorn	*Rhamnus cathartica*
flowering rush	*Butomus umbellatus*
common valerian	*Valeriana officianalis*
garlic mustard	*Alliaria petiolota*
giant hogweed	*Heracleum mantegazzianum*
giant knotweed	*Polygonum sachalinensis*
glossy buckthorn	*Rhamnus frangula*
Japanese barberry	*Berberis thunbergii*
Japanese knotweed	*Polygonum cuspidatum*
leafy spurge	*Euphorbia esula*
Morrow's honeysuckle	*Lonicera morrowii*
multiflora rose	*Rosa multiflora*
Norway maple	*Acer platanoides*
purple loosestrife	*Lythrum salicaria*
Phragmites	*Phragmites australis*
Scotch pine	*Pinus sylvestris*
Tartarian honeysuckle	*Lonicera tatarica*

B List Species

autumn olive	*Elaeagnus umbellata*
swamp thistle	*Cirsium palustre*

C List Species

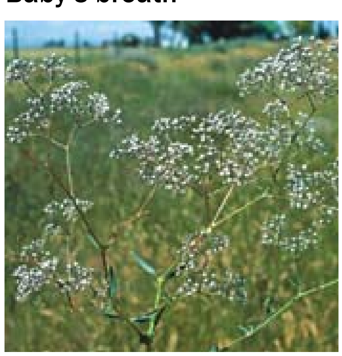
Canada thistle	*Cirsium arvense*
common St. John's-wort	*Hypericum perforatum*
curly pondweed	*Potamogeton crispus*
Eurasian water milfoil	*Myriophyllum spicatum*
reed canary grass	*Phalaris arundinacea*
spotted knapweed	*Centaurea maculosa*
variable-leaf watermilfoil	*Myriophyllum heterophyllum*

D List Species

common tansy	*Tanacetum vulgaris*
Japanese hedge-parsley	*Torillis japonicus*
moneywort	*Lysimachia nummularia*
European highbush cranberry	*Viburnum opulus*

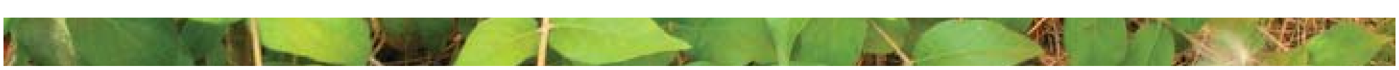
Giant hogweed

Baby's breath



Garlic mustard

Flowering rush



Invasive Species Treatment Efforts and Information

There are many successful treatment efforts underway in Michigan, but there is no single clearinghouse for invasive species information and no single entity coordinating action. The abundant information available on the treatment of invasive plants is not easily distilled into clear treatment recommendations for busy land managers. Due to lack of information, expertise, direction and/or dedicated funding, many infestations that could be nipped in the bud are ignored. Often, treatments are implemented without adequate site assessment or knowledge of important treatment details. The Wildlife Division will benefit from coordinating the knowledge of experts within and outside the Division to provide guidance on treatment priorities and monitor treatment effectiveness.

Much of the groundwork has been laid for organizing and transferring pertinent information to staff. A field guide featuring 47 invasive plants was produced and will be distributed to all Wildlife Division staff. It includes pictures of key characteristics of each plant, information such as habitat, reproduction and dispersal, and recommendations for rapid response actions. A companion invasive plant treatment guide featuring best control practices for high threat species is under development as is a compiled database of current treatments efforts and experts on state lands. This information will comprise the core of a centralized website that consolidates information and localizes it to Michigan's landscape.

Treatment goal:

To stop reproduction and dispersal using the best combination of techniques with the least negative impact:

- Hand-pulling, digging
- Cutting, mowing, discing
- Chemical control
- Prescribed fire
- Biological control
- Grazing

Early detection field training has been conducted in the Western Upper Peninsula, Eastern Upper Peninsula, and Northeast Lower Peninsula. Training on identification and control techniques was conducted in the Southern Lower Peninsula in 2008 and will be offered in the Northwest Lower Peninsula and Upper Peninsula in 2009. Assistance with prioritizing invasive species work will be provided to each management unit over the next several years.

Biological control involves the use of animals, fungi, or microbial pathogens, to control invasive plants. For widespread species such as garlic mustard and spotted knapweed, this may be the only realistic long-term option.

Michigan State University has partnered with MNDR, MNFI, and TNC to develop an on-line GIS-based mapping database and early detection alert system. The Michigan Invasive Species Information Network (MISIN), is designed to gather and aggregate invasive species distribution data statewide and train professional and citizen scientists on the identification of priority invasive plants. On-line training modules demonstrate identification characters using photos with a final quiz to test proficiency. MISIN will provide critical information for rapid response and prioritizing long-term control efforts.

Dedicated coarse scale surveys of high threat species and on-going technical assistance through contractors are recommended. Assistance can focus on field surveys, gathering data, prioritizing and implementing treatments, and monitoring and research. This will build internal capacity over time, positioning the Wildlife Division to make maximum use of resources as they become available.

St. Clair Delta - *Phragmites* research

The Southeast Wildlife Management Unit conducted a multi-year study of the selective control of invasive *Phragmites* using specific herbicide applications, prescribed burning techniques, mowing and flooding.

- The herbicide and burn treatments increased the percent canopy of natives and decreased *Phragmites*
- No suitable biological control agents were identified.
- The combination of herbicide broadcast, followed by the sequence of flooding, dewatering, burning, and flooding provided the most consistent control of *Phragmites*.


Photo: Elizabeth Czarapata

V. Managing Invasive Plants

Because invasive species are known to invade virtually every vegetation type and do not heed jurisdictional boundaries, they pose a serious threat statewide. Further, as global trade continues to expand, breaking down natural dispersal barriers, the number of potentially invasive species reaching Michigan is likely to grow. Given this scenario, addressing invasive species may seem like an impossible endeavor. However, there are means of focusing and coordinating efforts. The challenge is to identify important and winnable battles.

Primary emphasis should be placed on keeping highly invasive plants out of high value sites.

There is clear consensus that it is most cost effective to identify those species that pose the greatest threat to wildlife and direct actions towards prevention, early detection-rapid response, treatment of priority sites across all land ownerships where success is likely. This requires an understanding of what is valued, the level of threat posed by an invader, the extent and abundance of the invader across the landscape, and effective control techniques and costs. Managing invasive plants is essentially about prioritizing based upon identified values, management goals and threat of the invader. Primary emphasis should be placed first on keeping invasive plant species out of high-value sites.

It is helpful to consider the following key points:

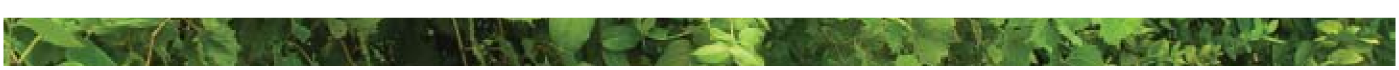
- Identifying and prioritizing places on the landscape that support wildlife values is essential—lacking this, prioritization of resources will be arbitrary and frustrating.
- Not all invasive plants are equal—they impact different wildlife habitats, and they have different life histories.
- Invasive species are not everywhere—but understanding where they are is essential to making effective treatment decisions.
- Treating infestations early is important—as infestations grow, the cost of treatment escalates, while likelihood of success declines.
- Important sites where success is possible should be targeted—otherwise resources will be wasted on unwinnable battles.
- Treating small satellite populations and seed producers first and managing upstream to downstream is smart—it can buy time for eventual containment of larger populations.
- Collaboration can be beneficial—working with partners and neighbors can extend resources and expand knowledge and success.
- Wildlife management is dynamic—what is considered harmful will change with values and as ecosystems evolve.

It is essential to take the time to plan the way to success, but is also important not to plan so long that little action is taken and good opportunities are missed. There will never be enough knowledge to proceed down a perfect path. The goals and objectives outlined in the strategy are designed to reflect the key points noted above so that logical action can be taken based upon current knowledge. The same principles can be used at any scale and can be integrated within Wildlife Division management plans.

Prioritizing Treatment:

- Value of site
- Threat posed by invasive plant
- Its extent and abundance
- Feasibility of control
- Availalble resources

The Wildlife Division initiated the release of *Galerucella* beetles to combat the spread of purple loosestrife.



VI. Vision for the Future

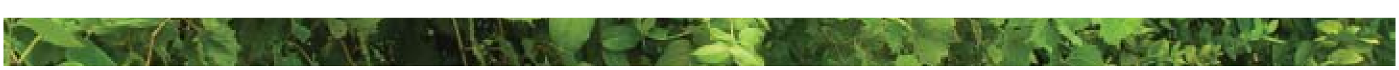
In order to develop achievable goals and objectives, it is important to visualize the desired outcome. The following vision was developed after reviewing all of the information gathered and discussed for the preparation of this document. It reflects the intended outcome of achieving the recommended goals and objectives.

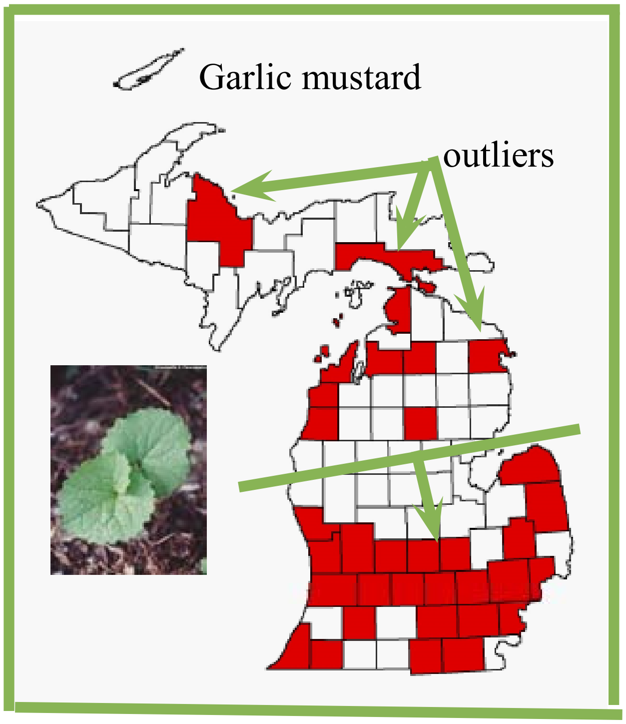
A centralized web-site has been established that identifies invasive plants that pose a threat to Michigan's wildlife and guidelines for action by species and region. The web-site serves as a Michigan-based clearinghouse of information on high threat invasive plant identification, impacts, distribution, control techniques, and model treatment and monitoring plans. It identifies taxonomic and treatment experts as well as on-going research and links to important regional and global information. A mapping database that can be populated on-line or by uploading data from multiple sources is operational for storing and tracking distribution data for high threat species. It is populated regularly by registered Wildlife Division staff and other professional and citizen scientists and distribution maps using aggregated statewide data are available for use in prioritizing action. The database has an automatic alert system to inform land managers and landowners when new detections of high threat species are reported. Regional strike teams are engaged to address new infestations that warrant a rapid response.

High value sites, established infestations, and dispersal vectors are identified and mapped by staff and partners. Sites of high value that are currently free from invasive plant are frequently monitored. State, regional and local staff define annual priorities for treatment based upon site value, level of threat, extent and abundance of the invaders, and feasibility of control. The general guideline of treating smaller, satellite populations and seed producers first and working back toward the larger infestations is considered, as well as containment of established source infestations and monitoring predicted pathways of spread. Trained staff, licensed contractors, and funds are available to treat prioritized sites. Resources, skills, and people are shared across jurisdictional boundaries where appropriate, and successful prevention, eradication, control, and restoration efforts are accomplished.

The distribution and treatment of invasive plants of concern are tracked over time and population trends and treatment results are assessed for the highest priority species. Research on new detection methods and treatments, including new biocontrol agents, is readily available and implemented where appropriate. The list of invasive species of concern is reviewed, progress on the strategic goals and objectives is assessed and priorities for the subsequent year are identified annually. Appropriate changes are made to the working invasive plant lists and overall strategies are revised as needed.

Photo: Maslowski/National Wild Turkey Federation





Treating smaller satellite infestations and working back towards the main infestation is frequently a useful approach. This concept can be applied at multiple scales.

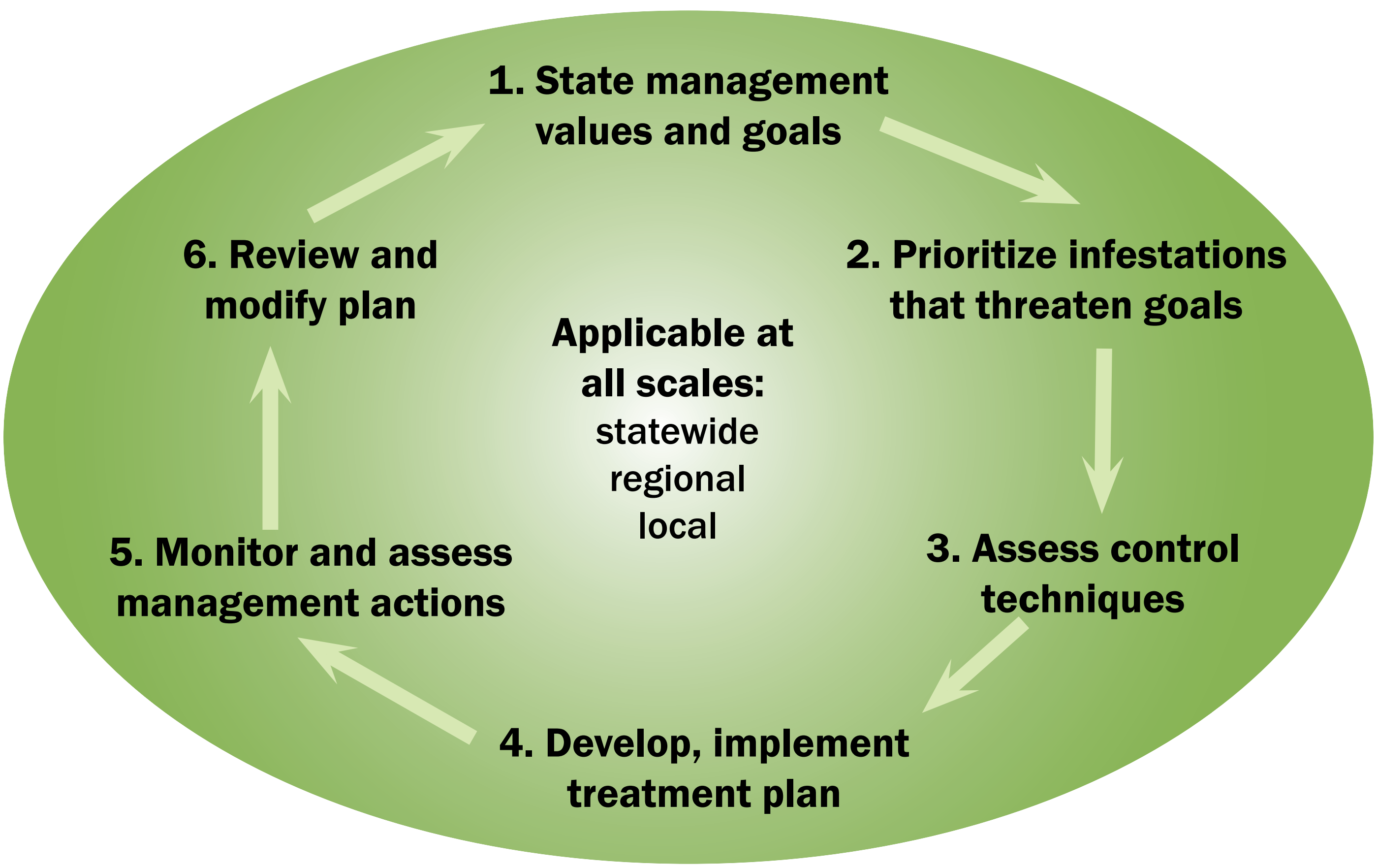
VII. A Strategic Approach

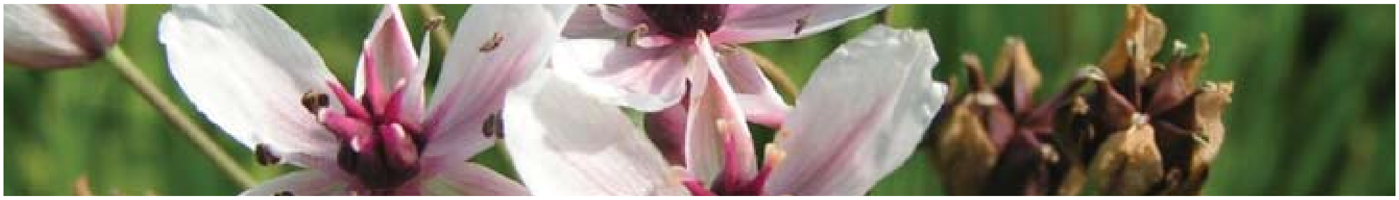
The strategic approach focuses on key goals and objectives organized around a cost-effective framework of early detection-rapid response, and long-term management at prioritized sites. It also recognizes the importance of leadership to set direction and empower staff, on-going assessment an research to help identify important, winnable battles, and education and outreach to improve and expand success through learning and adaptive management.

Six goals are identified, each with a set of recommended objectives. Several themes, common to all of the strategic goals, are presented as guiding principles. The regional lists of priority species presented in Section IV were developed as a tool to guide the decision-making required to attain the goals and objectives.

The framework does not identify specific values or management goals; these are identified through the Wildlife Division's planning processes.They are typically addressed on a site-specific basis. Is the site being managed for a particular game species? For timber harvest? For biodiversity? Are rare plants or animals present? The values and management goals associated with a site are an integral component of prioritizing action.

The framework also does not identify specific actions; this is the role of the statewide coordinator and regional point staff whose designation is recommended. The role of this team is to facilitate and coordinate action at statewide, regional and local scales, assess progress, and set new priorities annually. In order to do so effectively, it is recommended that the team define responsible parties and specific measures of success.





Guiding Principles

Knowledge regarding invasive plants is incomplete and constantly evolving. There is no one right answer to mitigating their negative impacts to wildlife and never enough resources to address them everywhere. However, several important themes intertwine through all elements of the strategic approach. They are presented here as guiding principles for determining and implementing specific actions to accomplish the identified goals and objectives.

Use of best available science **and commitment to integrating new information**

Knowledge about aggressive species and treatment practices is incomplete and evolving, yet managers must make decisions every day. The best a manager can and must do is identify wildlife values of importance and consider the most current scientific information available to prevent or minimize the spread of invasive plants to areas that compromise those values.

Prioritization **of treatment based upon values, threat, distribution, and feasibility of control**

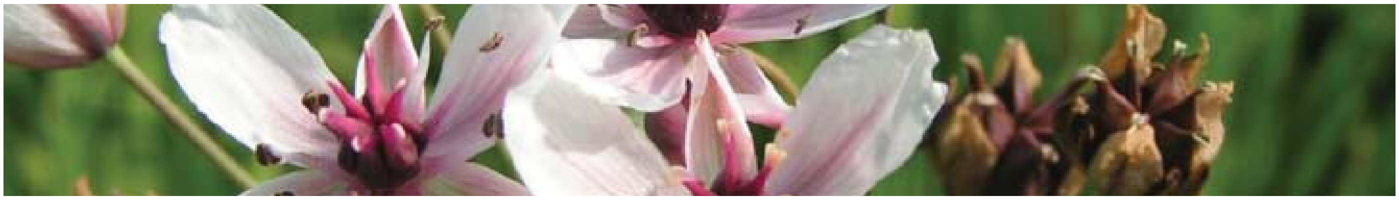
No amount of money or size of work force could possibly tackle all plant invasions successfully. It is essential that invasive species work be prioritized. Resources should be directed towards winnable battles at priority sites where success is likely, rather than towards efforts that are ineffective, unsustainable or unimportant. Priority sites should reflect identified wildlife values and emphasis should be placed on keeping invasive plant species out of high-value sites.

Collaboration **with partners to optimize solutions and share resources, knowledge and skills**

Invasive plants span all ownerships and cover types—no place in Michigan is immune to their impacts. Mitigation of negative impacts to wildlife will benefit from considering the perspectives of many disciplines and by sharing resources and skills. Finding ways to facilitate collaborative problem-solving is critical to achieving cost-effective solutions.

Monitoring **to ensure efficient and effective use of resources at all levels of the organization**

Monitoring is often the least considered or implemented element of land management, yet it is the essential link to determining if the desired results are being achieved. Monitoring is also necessary for assessing trends in the state. Tailoring monitoring to the level and type of treatment based on up-to-date knowledge will help maintain efficiency of effort.



Goals and Objectives

Goal I:

Leadership and Coordination—Ensuring Cost Effective Action

Facilitate the implementation of exemplary, science-based actions that eradicate or slow the establishment and spread of invasive plants that pose a threat to wildlife in Michigan.

State fish and wildlife agencies are well-positioned to lead the development development of strategies to combat invasive species.

Fish & Wildlife Conservation National Agenda Item

The threat of invasive plants is global and explicit recognition of their threat and costs of mitigating their impacts is urgent. Since invasive plants span all geographic ranges and most wildlife habitats, collaboration and coordination within MDNR and among partners is needed. Prioritizing action, monitoring success, and integrating new information across jurisdictional boundaries will help ensure effective use of resources. Wildlife Division leadership should designate resources and responsibilities to enable staff to work strategically across jurisdictional boundaries to address the threat of invasive plants.

Objectives:

1. Designate and maintain a statewide invasive species coordinator and regional point staff representing all management units and sections to implement the strategy and monitor progress.
2. Pursue and secure funding to address invasive species at appropriate scales.
3. Remove barriers to cross-jurisdictional action to facilitate rapid response and coordinated action.
4. Influence state and regional policies that minimize the establishment and spread of invasive plants.
5. Work with other states to gather and share information on the risk, spread, and control of invasive plants.

The NLP LIP began a public-private partnership with the Grand Traverse Watershed Group and multiple partners to implement a Phragamites early detection-rapid response program in Grand Traverse Bay.

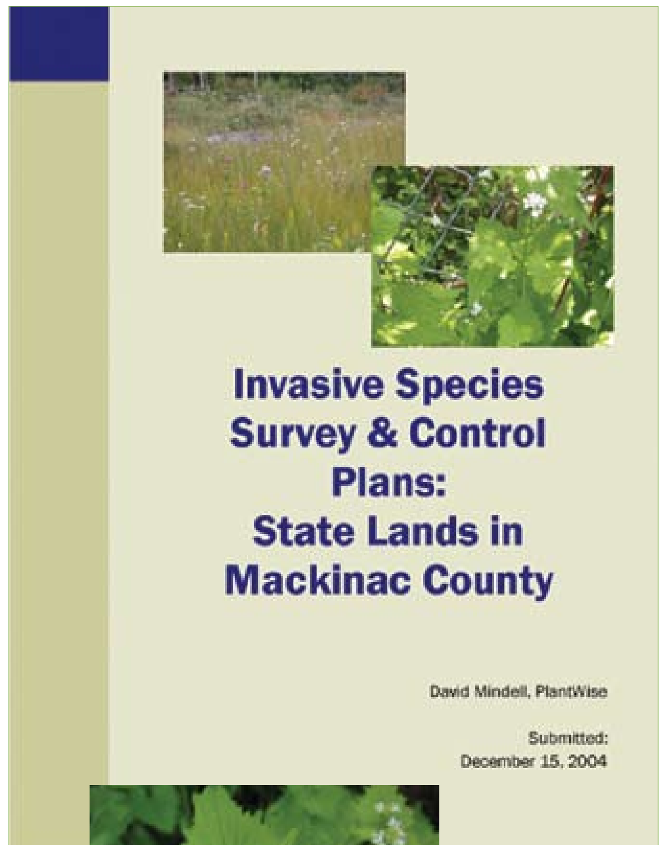
Goal 2:
Assessment and Research—The Pathway to Success

Assess the threat, status, and distribution of invasive plants that negatively impact wildlife species, natural communities, and ecosystems in Michigan.

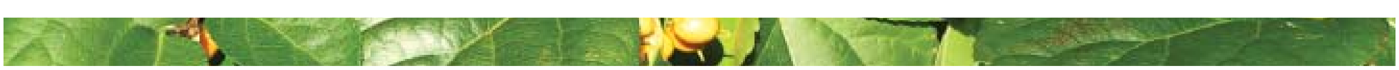
Accurate information on the biology, ecology, distribution, and threats of invasive plants is essential for determining effective treatments and prioritizing resources to reduce negative impacts. With good information, resources can be better directed towards places that are important for conservation of wildlife, using the most effective treatment techniques, and where success is likely. The Wildlife Division should work with partners to gather and analyze current data across all land ownerships and identify and implement research efforts to fill data gaps. This information should be distributed to the field in a way that provides guidance, while allowing local input to define specific actions.

Objectives:

1. Develop and maintain lists of high threat species for targeted prevention, eradication and control.
2. Establish a centralized GIS-based database to collect, house, and analyze distribution data for high threat invasive plant species.
3. Improve distribution maps for high threat invasive plant species.
4. Use predictive modeling to determine pathways of spread for high threat invasive plant species.
5. Promote research on ecological and economic impacts to plant communities and wildlife, control practices, and detection techniques for invasive plants.



The Eastern UP Wildlife Management Unit initiated a project to survey, map, rank sites, and determine the threats of garlic mustard (*Alliaria petiolata*) to natural communities & rare features in western Mackinac County.



Goal 3:
Prevention—The First Line of Defense

Prevent the introduction and establishment of high threat invasive species at state, regional, and local levels.

Investing in tools and resources for preventing invasive plants from arriving and establishing in Michigan or dispersing to new regions within the state is more cost-effective than treating populations that are well established. As populations grow, costs of treatment escalate quickly while likelihood of success decreases. Seeds and fragments can be spread by people, equipment, management practices, and through contaminated materials such as fill or mulch. The Wildlife Division should support regulatory policies and implement management practices that minimize the spread of invaders throughout the state.

Objectives:

1. Train staff on identification of invasive plants and best management practices.
2. Identify and address entry points and pathways of spread.
3. Adopt best management practices to minimize the introduction of high threat invaders to new sites.
4. Support policies and legislation that will decrease the impacts of invasive plants to wildlife.

A brochure on "Landscape Alternatives for Invasive Plants in Michigan" is available from the Midwest Invasive Plant Network (MIPN).

MIPN.org
Midwest Invasive Plant Network

USING CERTIFIED WEED-FREE FORAGE AND MULCH IN THE MIDWEST: A FACT SHEET FOR CONSUMERS

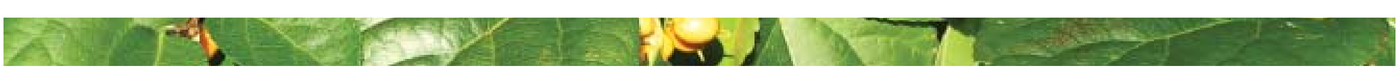
What are certified weed-free products?
Weed-free forage (hay) and mulch (usually straw) are produced throughout the country. Certified weed-free products have been inspected and confirmed to be free of the seeds of specific weed species. Each state in the Midwest has a certification program that is run by the state Crop Improvement Association, using standards developed by the North American Weed Management Association (NAWMA).

growing season starts, so that he or she can be sure to follow the procedures for weed-free crops and have the right type and quantity of weed-free products available for your needs.

How will I know which weed species have been excluded from my weed-free products?
NAWMA maintains a master list of species that may not be included in forage or mulch in order for the crop to be certified as weed-free. Each state also adds their state noxious weeds to the list. The NAWMA list can be found at www.nawma.org. Visit your state Crop Improvement Association's website (see below) to see additional species for your state. If there are particular species not on these lists that you would like to see excluded from the products you buy, you can contract directly with a grower to tailor the species list to your needs.

Invasive plants are often spread when forage and mulch crops contain their seeds. Michigan will benefit from the identification and use of weed free products.

Brushes to remove seed from boots.



Goal 4:

Early Detection and Rapid Response—The Second Line of Defense

Enhance MDNR Wildlife Division capacity to detect, report, and respond to newly detected introductions or localized outliers of priority invasive species.

Early detection and rapid response (EDRR) is currently the most effective means of slowing the spread of invasive plants. EDRR includes three components:

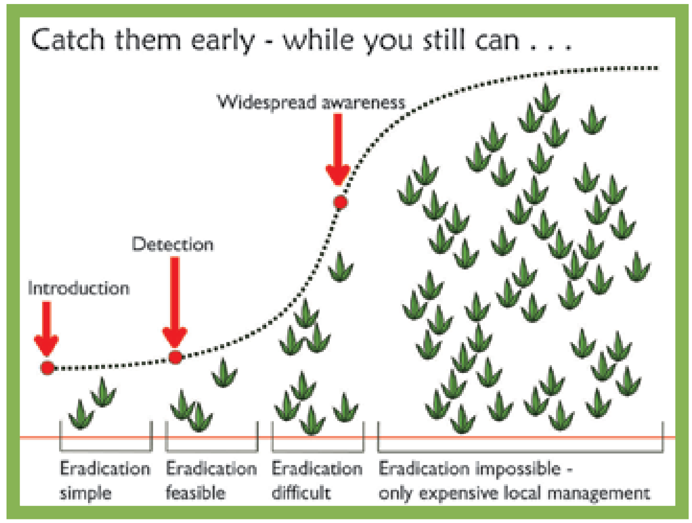
- verification of the detected invasive species
- assessment of the extent of the invasion and site conditions
- implementation of a treatment response

Responding without correctly identifying an invasive species, thoroughly assessing an infestation or understanding treatment techniques and timing can result in a failed response or even make the infestation worse.

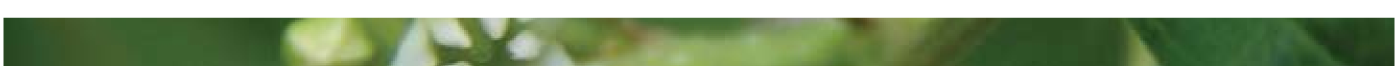
Staff should be on the look-out for new infestations during their daily activities and identify strategic sites for regular monitoring, such as high value sites, infestation boundaries, or key entry points such as public campgrounds. For most species there is an optimal survey time when detection is easiest. For some species, this can be in early spring before native species have leafed out, while for others it may be when the plant is in flower or fruit.

Objectives:

1. Establish a reporting, verification and alert system.
2. Train staff and partners in early detection and rapid response and monitoring techniques.
3. Develop rapid response and monitoring options for high threat species.
4. Establish regional response teams to conduct rapid assessment and treatment of newly detected infestations.
5. Implement detection monitoring at strategic sites.



Some invasive plants green-up earlier than other plants and can be targeted for detection and treatment in spring.



Goal 5:
Control, Management, and Restoration—The Third Line of Defense

Reduce the spread and harm caused by established invasive plants.

Few invasive plants will be eradicated in Michigan, however their spread and impacts can be minimized by implementing effective control techniques. The goal is to remove, reduce, or contain infestations by stopping their reproduction and dispersal. It is important to direct resources towards species that pose the biggest threat at important sites where success is likely. Guidance on highest threat species is provided by the regional lists presented in Section IV. These lists will improve as information on the threat, ecology, and distribution of high threat species is gathered over time. Important sites include places that are valued for wildlife, sites where established infestations that can be contained or restored over time, and sites that serve as rapid vectors for spread, such as roads. Likelihood of success is determined by considering the extent and abundance of the infestation, known effective control techniques, specific site conditions and available resources.

Prioritizing is both an art and a science that will shift with identified values, scientific information, available funds, social climate and opportunity—there is no single right answer. Because resources are limited and distribution information is incomplete, prioritizing where treatment occurs is probably the most difficult aspect of mitigating invasive plant impacts. For this reason, it is important to engage with other partners to garner additional resources to address priority sites. The Wildlife Division can play an important role in directing efforts of willing helpers.

Once priorities have been determined, it is critical that control techniques and timing are fully understood. Using a technique incorrectly or at the wrong time can make things worse.

Objectives:

1. Develop manual of control practices for treating invasive plants.

2. Establish and implement processes for prioritizing action at state, regional, and local scales.

3. Establish and implement protocols for documenting treatments, expected outcomes, monitoring, and measures of success.

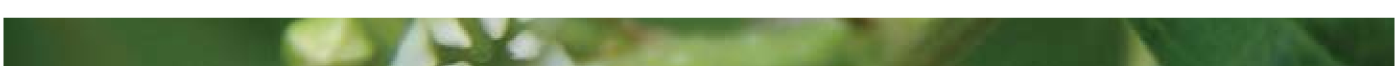
4. Train staff to prioritize, implement and monitor treatments.

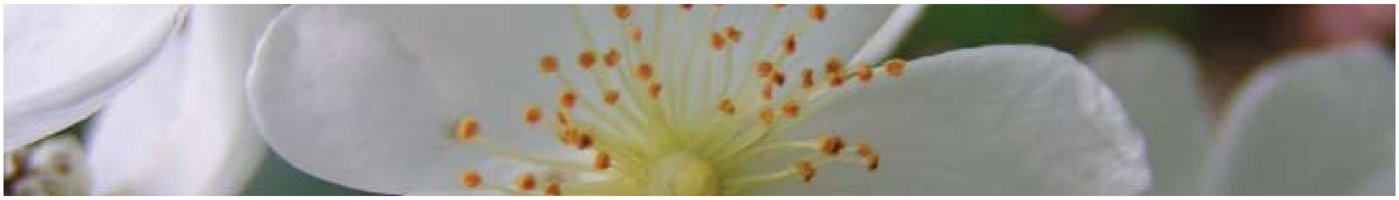
5. Assess. implement and monitor prioritized treatments and monitoring.

6. Rehabilitate sites and restore key ecological processes where appropriate.

Causes of Treatment Failure:

- Unrealistic goals
- Inadequate assessment
- Ineffective techniques
- Lack of follow-through
- Inadequate capacity/knowledge





Goal 6:

Education and Outreach—Improving and Expanding Success

Provide educational opportunities and products to professional and public audiences to increase awareness and capacity to more effectively mitigate invasive plant impacts

Invasive plants can be addressed more effectively when their impacts and successful responses are communicated widely. Sharing and soliciting information on the distribution and treatment of high threat species will help direct public and professional audiences towards activities they can participate in to help meet the challenge of invasive species. Direct engagement with diverse audiences also demonstrates the importance and quality of the Wildlife Division's work, thus bolstering support and fostering new relationships.

Objectives:

1. Deliver educational events and products using multiple formats and media, such as: public demonstration days, workshops, brochures, press releases, on-line tools, and videos.

2. Establish and maintain a web site that provides one-stop shopping for information on invasive plants that pose a threat to wildlife in Michigan.

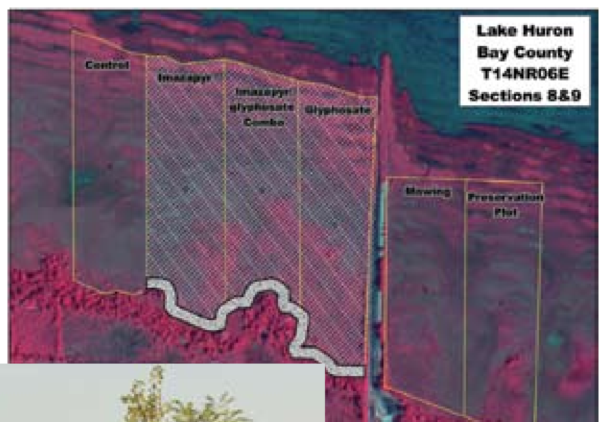
3. Share and gather invasive plant information at professional meetings and conferences.

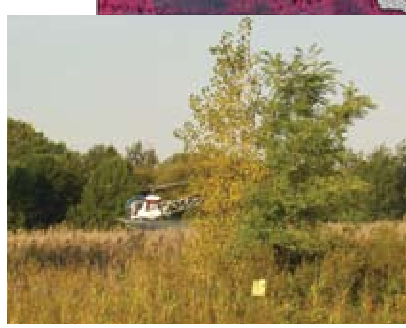
4. Place signs at high risk entry points and other strategic sites with information on high threat invasive plant identification, impacts, and preventative practices.

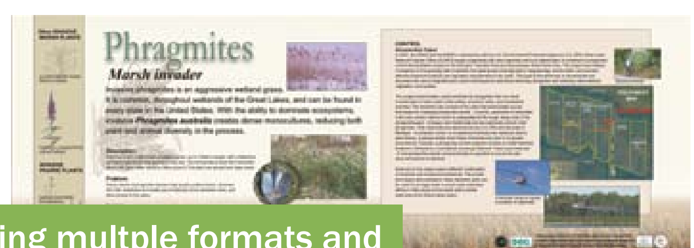
5. Provide volunteer opportunities to assist in the detection, treatment, and monitoring of high threat invasive plants.

Saginaw Bay *Phragmites* Demonstration Project

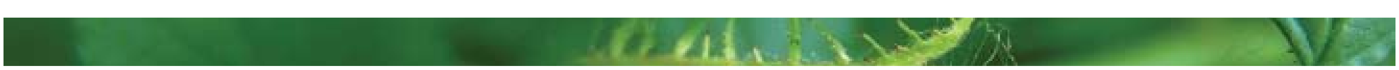
The Michigan Department of Natural Resources has partnered with the Department of Environmental Quality and Ducks Unlimited in a multi-year project to demonstrate techniques for controlling *Phragmites*. The latest phase of the project demonstrates several selective control treatments of *Phragmites* in mixed communities where native species are preserved.

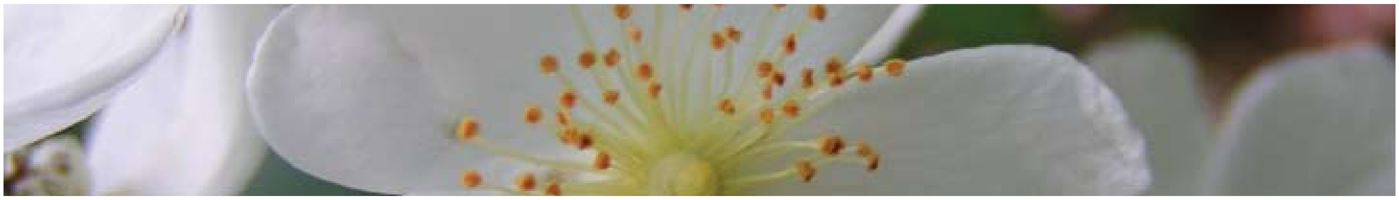






Deliver educational events and products using multple formats and media such as public demonstration days, workshops, brochures, press releases, online tools and videos.





VIII. Monitoring and Updates

Successful mitigation of negative impacts from invasive plants requires the incorporation of new information derived from monitoring treatments and research. It is recommended that the responsibility for reviewing progress and setting priorities for the next year be assigned to the statewide coordinator and regional point staff. The coordinator should solicit input from staff and partners and submit a progress report to the Wildlife Division Management Team with recommendations for improvement. Priority actions, timelines, and measures of success for the subsequent year should be identified. As a long-term goal, this report can become an assessment of invasive plant population trends, impacts, and best control practices for the state.

Since the understanding of the impacts of and ecology of invasive species is constantly evolving, the premises upon which the plan is built should be reassessed periodically. Ecosystems are dynamic and new relationships between species, both native and non-native, will evolve over time, as will human values.

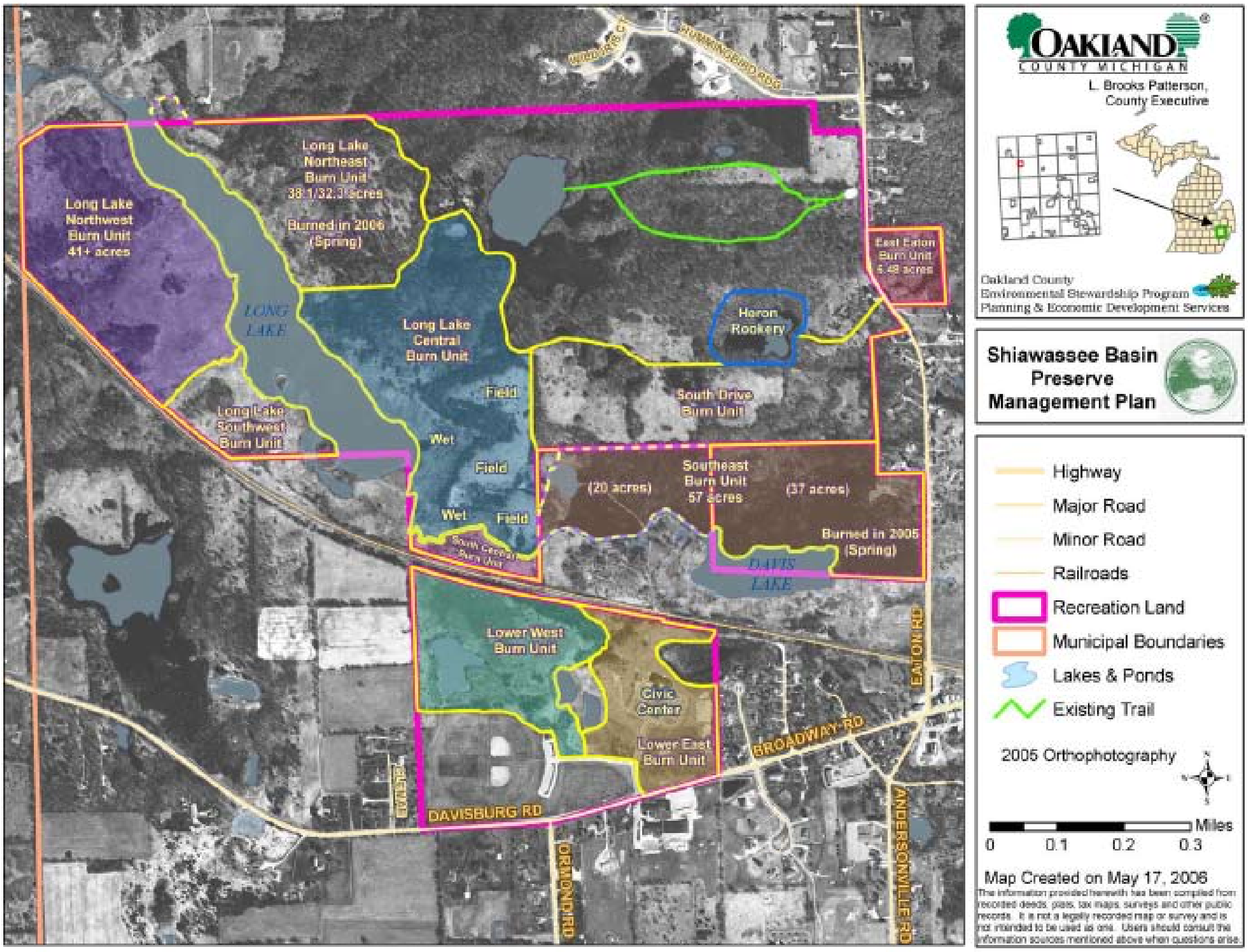
Treatment and monitoring of *Phragmites* in St. John's Marsh shows dramatic results.

Before treatment

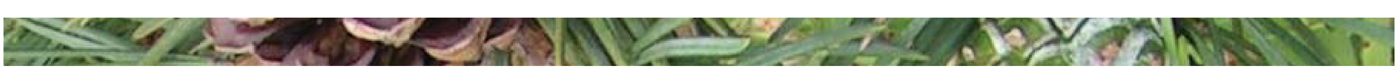
Post herbicide

Post burn

2 years later



Wildlife Division LIP biologists partnered with Springfield Township and others to manage a high quality site supporting rare species in Oakland County. Many invasive plants will be treated and monitored.



IX. Other State Programs

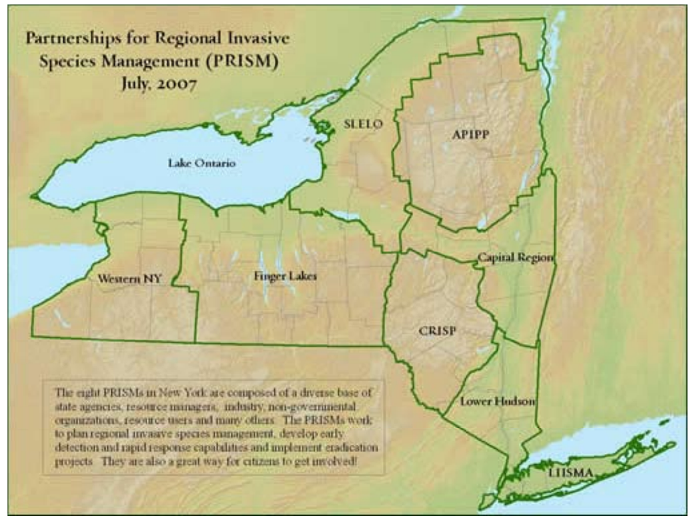
Further examination of invasive plant species programs that have been successful in other states will be useful as the strategic approach presented in this document is implemented and evolves over time. Several examples are described briefly below.

Wisconsin DNR has an interdivisional invasive species team, employs an invasive species outreach coordinator and a mapping specialist that focuses on early detection/rapid response. They have extensive educational literature on the DNR website that covers both animals and plants, aquatic and terrestrial species. They have developed a classification system for invasive species and have proposed over 40 species for legal regulation. They work cooperatively with the Invasive Plant Association of Wisconsin and are part of the Wisconsin Council on Invasive Species, which is an interdepartmental team set up under statute.

New York has a nuisance and invasive species program. They have an interdepartmental task force and grant $2 million to invasive species control programs, which are split between aquatic and terrestrial species.

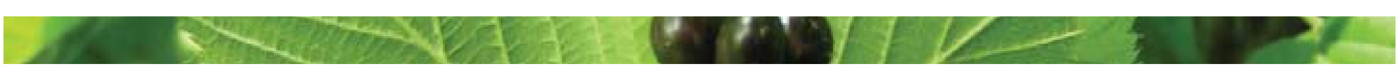
Ohio DNR has a variety of educational items on their website and works cooperatively with other agencies and organizations through the Ohio Invasive Plant Council.

Indiana DNR conducts education about invasive species through their Landowner and Community Assistance Program and regulates nurseries through their Division of Entomology and Plant Pathology. They serve on the Indiana Invasive Species Task Force and include all plants and animals in their purview.



The New York Invasive Plant Council has developed an Early Detection list for each of their eight PRISM regions.

USFS staff discovered garlic mustard at Foote Dam and contacted Wildlife Division. They partnered with Consumer's Energy, MDNR Parks Division, and the Michigan Audubon Society to treat this site.



X. Alternatives for Implementation

Currently, all other public land agencies, many conservancies, land trusts, and some private landowners across the state are actively addressing invasive plants. While there are important control efforts being conducted by the the Wildlife Division, they are somewhat disjointed and lack a statewide focus on priority wildlife habitat goals and high value sites. Without a comprehensive, coordinated approach, action will be inefficient, sometimes ineffective, and often blind to the most cost-effective tactics. For example, an aggressive early detection and rapid response program on state lands does not exist and little effort is directed towards modeling and monitoring predicted pathways of spread. These are critical actions required for a proactive approach. Without dedicated, strategic action on state lands, invasions will progress more rapidly across all lands. Given the costs to wildlife and public image, this is not considered an acceptable option.

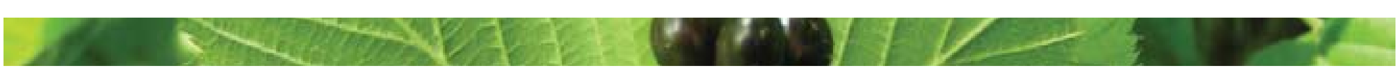
The goals and objectives presented in Section VII are designed as a comprehensive framework for action. They can be addressed in many ways. Three options considered were rejected as less than optimal. These included:

- contracting out all invasive plant work to other entities,
- designating all work to be undertaken solely by the Wildlife Division, or
- designating the work to be undertaken by Wildlife Division in collaboration with the other MDNR Divisions.

The first option is expensive and inefficient and does not capitalize on Wildlife Division expertise, bodies on the ground, and planning processes that can and should incorporate invasive plant work. The second option is not realistic as current staff resources and skills are limited, and other duties consume much of staff time. The third option could theoretically work under the leadership of experienced MDNR staff. However, limited capacity and resources currently make this an unrealistic option as well.

A fourth option is to phase in the integration of invasive plant work into the Wildlife Division's activities using contracted technical assistance. This is considered the most viable option. The Wildlife Division requires training and time to build sufficient skills, internal capacity and resources to successfully address the strategic goals and objectives outlined in this framework. While the approach presented is directed towards the Wildlife Division, collaboration with other MDNR Divisions and non-MDNR partners is essential. The threat of highly invasive plants is common to all lands in Michigan, and all of Michigan's citizens will benefit from sharing and directing skills and resources towards the same end goal.

The option of identifying specific actions, responsible parties, timelines and measures of success for the goals and objectives was also considered for inclusion in this document. Input from the Wildlife Division Management Team indicated that this was not a preferred option. Rather the strategic approach should provide a broad framework but allows flexibility in determining actions, roles, timelines and measures. The Division currently faces much uncertainty regarding available resources and staff, as well as outcomes of various on-going planning processes. A designated statewide coordinator and regional point staff will be better positioned to identify specific actions best suiting the evolving needs of the Wildlife Division.



XI. Appendices

A. Regional Meetings - Agendas and Notes

B. County Distribution Maps

C. Master List of Invasive Species

D. Annotated Bibliography

E. Key to Page Invasive Species Photos

Appendix A. Regional Meetings - Agenda and Notes

DNR Wildlife Division Invasive Plant Species Meetings

Western Upper Peninsula: Marquette

April 8, Northern Michigan University – Bottum University Center

Eastern Upper Peninsula: Newberry

April 9, 2008, Super 8 Motel - Zeller's Restaurant

Northern Lower Peninsula: Roscommon

March 27, 2008, Ralph A. MacMullan Conference Center

Southern Lower Peninsula: East Lansing

March 20, 2008, Michigan State University - Diagnostic Lab

AGENDA

9:00	Welcome, introductions and purpose of meeting
9:20	Setting the stage – what we know about invasive species
9:50	Break
10:00	Providing input - what species and issues are you struggling with?
10:30	Developing the strategy – speed brainstorming
11:30	Prioritizing
12:00	Lunch
1:00	Report and discussion
2:00	Adjourn

Summary Notes from Regional Invasive Plant Meetings

Regional Invasive Plant Meetings Participants:

Southern Lower Peninsula

Chris Hoving (WLD)
Dan Kennedy (WLD)
Dave Dominic (WLD)
Doug Pearsall (TNC)
Earl Flegler (WLD)
Jennifer Kleitch (WLD)
Jim Hazelman (USFWS)
Joe Robison (WLD)
John Niewoonder (WLD)
Jon Curtis (WLD)
Kristin Bissell (WLD)
Mark Sargent (WLD)
Phyllis Higman (MNFI)
Ray Rustem (WLD)
Ryan O'Connor (MNFI)
Sue Tangora (WLD)
Todd Hogrefe (WLD)
Tom Ward (NRCS)

Northern Lower Peninsula

Abby Gartland (GTRLC)
Bob Clancy (Parks)
Brian Piccolo (WLD)
Doug Pavlovich (WLD)
Larry Vissar (WLD)
Mark Sargent (WLD)
Mike Donovan (WLD)
Phyllis Higman (MNFI)
Ruthann French (WLD)
Steve Griffith (WLD)
Sue Tangora (WLD)
Valerie Frawley (WLD)

Eastern Upper Peninsula

Bruce Leutscher (NPS)
Don Kuhr (FMFM)
Greg Corace (USFWS-Seney)
Jackie Pilette (Little Traverse Bay Bands)
Jim Waybrandt (Fisheries)
Kerry Fitzpatrick (WLD)
Kristen Matson (FMFM)
Les Homan (FMFM)
Mark Sargent (WLD)
Matt Edison (FMFM)
Phyllis Higman (MNFI)
Sara Davis (USFS)
Sherry MacKinnon (WLD)
Sue Tangora (WLD)

Western Upper Peninsula

Angie Lucas (Hiawatha National Forest Native Plant Program)
Bob Heyd (FMFM)
Bob Kahl (Moosewood Nature Center)
Christie DeLoria (USFWS)
Danielle Miller (TNC)
Eric Thompson (FMFM)
Geri Larson (Superior Watershed Partnership)
Jason Mittlestat (FMFM)
Jerry Mohlman (FMFM)
Jim Ferris (FMFM)
Kerry Fitzpatrick (WLD)
Linda Lindberg (FMFM)
Liz Coyne (Alger Conservation District)
Marilyn Shy (NRCDS)
Mark MacKay (WLD)
Mark Sargent (WLD)
Miles Falck (GLIFWC)
Monica Joseph (WLD)
Phyllis Higman (MNFI)
Rob Aho (WLD)
Sue Tangora (WLD)
Terry Miller (USFS)

Species currently identified by participants as problematic:

Southern Lower Peninsula
Autumn olive
Baby's breath
Black alder
Black locust
Common buckthorn
Dame's rocket
Flowering rush
Garlic mustard
Glossy buckthorn
Hogweed
Honeysuckles
Common privet
Japanese barberry
Japanese knotweed
Lyme grass
Multiflora rose
Ornamental grasses
Narrow-leaved cattail
Oriental bittersweet
Phragmites
Purple loosestrife
Reed canary grass
Spotted knapweed
Swallow-wort
Teasel
Thistles
Wild parsnip

Northern Lower Peninsula
Autumn olive
Baby's breath
Black swallowwort
Bladder campion
Glossy buckthorn
Garlic mustard
Hogweed
Honeysuckle
Hydrilla
Japanese barberry
Japanese knotweed
Leafy spurge
Lyme grass
Multiflora rose
Oriental bittersweet
Phragmites
Purple loosestrife
Reed canary grass
Spotted knapweed
White sweet clover
Wild parsnip

Eastern Upper Peninsula
Autumn olive
Baby's breath
Centaurea diffusa
Eurasian water-milfoil
Forget-me-not
Garlic mustard
Glossy buckthorn
Goutweed
Honeysuckles
Hybrid cat-tail
Hydrilla
Japanese knotweed
Japanese stilt grass
Leafy spurge
Multiflora rose
Periwinkle
Phragmites
Purple loosestrife
Scotch pine
Spotted knapweed
Sweet white clover
Watercress
Wild parsnip

Western Upper Peninsula
Autumn olive
Baby's breath
Bull thistle
Burdock
Canada thistle
Clusterhead pink
Common buckthorn
Eurasian swamp thistle
Eurasian water-milfoil
Glossy buckthorn
Goutweed
Hawkweeds
Hound's tongue
Hydrilla
Japanese knotweed
Leafy spurge
Lyme grass
Multiflora rose
Phragmites
Reed canary grass
Scotch pine
Spotted knapweed
St. John's wort
Wild parsnip

Difficulties identified by participants in dealing with invasive plants – comments provided by spokesperson for each management unit or agency:

DNR Directives/Direction

- Not formally recognized as priority at top
- DNR priorities unclear
- DNR staff roles are unclear
- Need framework and criteria to ID values across agencies
- Need to identify common goals that drive action
- Need common language and understanding of the issue that distinguishes between science and value driven decisions
- Need Department and Division Coordinators
- Need point people by ecoregion and/or management unit; no one currently assigned
- Need support at all levels to do work
- Need WLD policies for guidance that is consistent with Law, DNR policies, WAP, Forest Certification, etc.
- Need emphasis on EDRR
- Need statewide, regional, & local priority list for EDRR
- Need regional and local priorities to assist control/management choices
- Need to address invasives regionally across all ownerships
- Loaded terms (invader vs colonizer)
- Inconsistency across units
- Need priority for burns
- Need to demonstrate economic impacts to values: e.g., ecosystems, recreation, hunting, fishing, etc.
- Need a statewide detection alert system
- Not efficient to certify everyone – use contractors or certify statewide team, or staff who will use it immediately
- Statewide team or contract vs internal staff

Values

- Need framework and criteria to ID values across agencies
- How do we reconcile managing against invasive species with the fifth principle of ecosystem management: we do not attempt to freeze ecosystems in a particular stage
- Conflicting values, e.g., some invasive species good for wildlife
- How do we draw a line between acceptable and unacceptable invasive species?
- Does it matter how a species arrived in Michigan to determine if we manage against it?
- Does it matter that the rate of new species is more rapid than historic records?
- Does it matter that many of our communities are altered and the loss of exotics may not be to the benefit of wildlife species?
- Evaluate based upon wildlife services
- Need education to change attitudes prior to infestations becoming unmanageable
- Do we value specific ecosystem types or ecosystem function (including novel systems)?
- Resource goals should drive invasive species priorities

Mapping/reporting infestations

- Report negative findings too
- Data standards – collection and storage
- Documentation of data and protocols
- Need remote sensing mapping equipment, techniques, & expertise
- Need simple report line
- Need to involve all divisions in reporting

Detection and Control Efforts

- Lack of monitoring
- Long term commitment
- Challenging treatment sites
- Hard to identify best treatments
- Lack of control technology, knowledge
- Struggle with fire as a control method
- Need easier way to release Galerucella beetles, especially on private land
- Ethics: when is it OK to conduct research vs. controlling invader (best treatment, predictive modeling, experimental designs)
- Need restoration after control to regain values
- Need expert consultation
- Hampered by complexity of permitting
- Need cross-jurisdicational capability
- Need to know priority species
- Need rapid response process
- Regional coordinators and SWAT teams
- Need methods, recipes, permits
- List of licensed applicators
- Need equipment
- Need follow-up on oil and gas rigs
- Need local disposal mechanism
- How to decide if treatment is appropriate – should be driven by multi-scale protection and restoration of values
- Need to work with shipping entry of new species
- Need to demonstrate economic value of EDRR vs. long-term control

Knowledge/Education/Information

- Which species are a problem
- How to identify
- What habitats/cover type by species
- Prioritizing control
- Mapping
- Control by multiple partners
- Too much information; need to make relevant information easily accessible
- Public awareness
- Lack of education
- ID, biology, control, BMP's
- Information on pathways of spread
- Need centralized web-site
- Need predictive models
- Need center for ID confirmation
- Need local expertise
- How to distinguish between native and non-native, e.g., Phragmites
- How to prioritize, e.g., ability to use landscape perspective to make 'right' local decision; how to decide if treating a particular infestation is appropriate

Dispersal of invasive plants

- Sources of weed free gravel/mulch
- MDOT road mix
- Fire equipment moving seed from south to north
- Public use – transport seeds
- Need BMP's to help block vectors
- Need predictive models

Resources/capacity

- Lack time, money, & people for effective action
- Lack of native plants for restoration
- Need remote sensing mapping equipment, techniques, & expertise
- Lack of trained personnel
- Lack of point person (s)
- Need more licensed pesticide applicators
- Lack of qualified herbicide applicators – there has been a shift fewer certifications
- Unrealistic goals
- Understand local contractors
- Which consultants are capable, available
- Capacity building needed
- Need local expertise in each mgmt unit
- Need travel flexibility to respond
- Need to work with partners to increase capacity
- Define rapid response, what and how
- USDA, RC&D can provide support for building capacity & training

Coordination with others

- Need framework and criteria to ID values across agencies
- Need regional coordinators
- Communication with local agencies
- Coordination with other agencies
- MOU details, legalities, compatibility
- Working on private lands; need to address all lands
- MOU with NPS and DNR
- Point person – no one currently assigned - by ecoregion or management unit
- Assist or participate in Cooperative Weed Management Areas
- What is USFWD Role/niche?
- Need to share information
- Need to coordinate work across partners
- Data management and sharing
- NRCS can apply for funds that MDNR can't
- MDOT needs to involved

Funding

- Lack of long-term funding
- Inmate crew raise prices
- Need better demonstration of economic impacts
- Inconsistant across mgmt units
- Cooperative Weed Management Areas are eligible for some additional funding sources
- NRCS can apply for funds that MDNR can't
- Need specific funding for USFWS work on invasives

Policies/legislation

- Can we apply herbicide that is pre-mixed?
- Work instruction require certification?
- Permitting process is complicated/restrictive
- Some people still selling non-natives
- Lengthy process of regulations vs speed of invasion
- Need stronger legislation

Other, parking lot

- Raising gas prices
- Next steps and communication re this process
- Plan needs to be clear on science vs. value decisions
- Earth worms
- Mute swans

Comments from brainstorming and group discussions on specific topic areas:

- Wild pigs- bounty needed

I. DNR Management/Statewide Council

- Modification of "greater DNR" mission?
- Planning, Forest Certification, WAP – possibly be a driver
- DNR needs to prioritize time and $ if this is important (reality is field may decide it's a priority, but funding comes from Lansing)
- DNR (FMFM) needs more unit level commitment to dedicated invasive control projects. Identify roles for responsibility – not just get down what is possible above and beyond normal job duties
- Someone needs this in their job description or it won't be a priority
- Need work instructions, directives, etc.
- What else comes off the plate if this comes on?
- Need immediate action, not just talk
- Need baseline funding
- Embrace EDRR in regions of the state where we can have a dramatic impact

II. Prevention and Early detection/Rapid Response

- Identify invasive species as a DNR/WD priority issue at the top
- Identify prevention, early detection, and rapid response efforts as a high priority
- Allocate funds to establish and implement an EDRR strategy
    - Review successful models such as New York Prism system, Minnesota, Florida, New England IPANE, Debbie Mauer (Chicaco)
    - Must cross all landownerships
    - Data management and quality control
    - Coordination with neighboring states and landowners
    - Assessment and implementation of appropriate response (need clear direction on when to initiate a response and how)
    - Establishment of monitoring protocol
- Identify and train dedicated statewide, regional, and local point person (staff) to verify reported occurrences, coordinate, and implement appropriate response; make this part of their PD
- Develop prioritized hit list at statewide, regional, and local scales (to be reviewed semi-annually)
    - Learn from neighboring states, regional groups, etc.
- Develop ground rules for addressing invasive species (who, when, how, which species…)
    - Annual survey and assessment (tied to best detection time and high risk areas)??
    - How to report and map
    - How to assess if rapid response is appropriate
    - Rapid response practices and protocols
    - Monitoring protocols
- Identify and train dedicated statewide, regional, and local point people to verify reported occurrences and coordinate appropriate response; make this part of their PD
- Use IfMap - all field staff and all divisions need to be involved
- Establish central, rapid hot line for all management agencies; capability to confirm ID
- Establish automatic e-mail alert when new occurrences are reported
- Train DNR (including fire officers, foresters) & other agency field staff to recognize high threat species, gather minimum information to assess if rapid response is appropriate, report new in-

festations via established mechanism, and alert appropriate people to implement response

- Assemble rapid response teams as part of CWMA's or other regional groups working on invasives (need internal response teams too?)
    - Ensure that appropriate permits and authorities are in place in advance
    - Provide necessary equipment, materials, and expertise
- Develop best management practices for forest and wildlife treatment and other disturbance areas to minimize spread of unwanted invaders
- Concentrate detection on locally special areas or high risk area – establish local team to identify what and where these are
- Assemble known rapid response control techniques and share among users; include revegetation options
- Determine what is acceptable collateral damage from control efforts (should be part of treatment plan justification)
- Train (and license) designated field staff to carry and use hand-operated spray bottle of herbicide in vehicle to allow rapid response on appropriate occurrences
- Identify other pathways of spread and develop best management practices and regulations such as boat cleaning stations
- Establish protocols for cleaning equipment (i.e. campground mowers, fire equipment) boats/lake access (appropriate facilities) or find alternatives that limit spread by equipment, boats…
- Figure out how to minimize spread by unclean gravel, sand pits, and mulch (DNR, MDOT, etc.) and establish protocols
- Conduct education and outreach to public, retailers; provide native alternative lists
- Establish centralized, one stop website, like that for EAB, available to all landowners
    - Priority #1: describes the real risks by species (invasiveness assessments)
    - Priority #2: identification – good pictures of critical stages of critical species
    - Priority #3: how and when to report and treat a newly detected infestations
    - Priority #4: recommended rapid response actions, hand pull; specific herbicide recommendations, etc.
- Put up information signs at recreation and tourist (high use) locations
- Clean boots when traveling
- Prevent invasive plant landscaping
- Limit vehicular access to high value areas
- Improve spatial planning of buildings (to minimize introduction to priority places by disturbance?)
- Explore opportunities to use volunteers and other field staff from various agencies to assist
- Local disposal

III. Prioritizing Control and Restoration Efforts

- Identify and implementation cost-effective control efforts as a Division/Departmental priority, as the next line of defense after prevention, early detection, and rapid response
- Allocate funds to selected staff within each management unit, (possibly more locally than that) to coordinate the prioritization process
- Allocate funds to conduct rapid, coarse scale mapping to better assess priorities and feasibility of control (mapping standards and protocols needed)
- Establish statewide, regional, and local process for prioritizing cost-effective control projects
    - Establish invasive species work group with representation from each Management Unit and statewide coordinator should make decisions regionally; need to get other agencies on board
    - Tie this to identification of management goals and values (need to ID high value

sites)

- Ideally would cross all land ownerships and consider state, regional and local scale concerns
- Priorities will vary regionally and locally
- Higher priority should be given to vulnerable species and ecosystems; rare communities and habitat types (e.g., pine barrens, oak savanna, dunes, fens, etc.)
- High priority should be given to invasions contributing to local decline of T & E species
- Timber, deer, turkey will be impacted should drive the long-term need to be a priority
- Need rapid response to new arrivals – do NOT wait to see if a major problem
- Eradicatioin should be a priority when any newly naturalizing species is found, regardless of invasiveness because of lag time, followed by explosion that is often observed, e.g., bush lespedeza at Rose Lake, Frog-bit, landscaping ornamentals (this is perhaps done at a local scale, but only if practical – would rather have $$ go to things that we know are a problem and are feasible to control)
- GIS maps with priority areas identified should be available to all
- Identify areas that are important to wildlife, e.g., waterfowl stopover and breeding areas
- Will often include eradicating outliers and moving back towards sources
- Private lands should be prioritized because of most habitat is on private lands
- Need to know where invasives have already taken hold vs where they have not
- Suggestion that private landowners will pay for control on their lands
- We likely can agree on a handful of high threat species that we should address, and many that would be unrealistic to address; the harder part is which species in between – if we take a site based approach, it would be any that are threatening our management goals
    - Use predictive models of spread to help ID important control areas
- Establish mechanism(s) for determining cost-effectiveness based on established models, e.g., TNC "Weed Management Template" which takes into account value of the site, potential threat of the species, abundance and distribution of the species, and feasibility of control
    - Sites identified for control based upon value trying to protect
    - Species identified control where low in abundance, yet very high potential threat
    - Vectors of spread (high use areas, gravel pits, campgrounds, trailheads)
    - How much assessment (survey) is needed before deciding on a strategy for attack
- Establish standards for invasive species control projects that include:
    - justification for action based upon overall management goals
    - specific treatment plan and anticipated outcome
    - long-term monitoring plan and needs
    - distinguish between eradication, control, restoration; can you have control without restoration?
- Train staff in site assessment, prioritization of control actions, specific control techniques, and monitoring
- Allocate funds to implement and monitor prioritized control efforts whether by contract, collaboration, or internally, where success is likely and long-term efforts can be assured
- Work with neighbors to capitalize on financial and ecological assets or detriments (invasive

transport downstream) LIP $$ can be used on reed canary grass, purple loosestrife, and Phragmites

- Establish centralized database of best control practices and monitoring protocols, with access to up-to-date, localized information and experts; stewards blog/list-serve for on-going discussions
- Techniques are important , including use of native species where needed after invasives are removed
- Develop approved list of who can do control work and what kind of techniques
- Collaborate for small and large scale efforts
- Partner with established volunteer efforts – can perhaps direct them to more successful actions
- Do no harm

IV. Monitoring
Work with other entities

A. Monitoring for detection of new infestations

- Need to evaluate when to monitor vs when to kill – part of EDRR protocol
- Formalize/sanction data collection as a function of forest inventory (FIA)
- Common database with quality control and quality assurance– systematic surveys, beginning with areas of higher value
- Could add protocol on invasive sampling during forest inventory to expand monitoring at low cost
- Statewide database of location and status available to all resource mgmt groups for data input and output
- Use school programs (education systems) to monitor
- Work with entities that are frequently in the field to gather location data; provide incentives for participation (mail carriers, road commission, other outdoor and nature groups, e.g., Michigan Audubon Society, Michigan Botanical Clubs, etc.
- Quality control and short-term and long-term tracking in changing status of individual sites needs to be built into any data management planning as does a user access/security plan (e.g., who can post)

B. Monitoring Management Impact – how successful was the control effort

- Identified as a serious deficiency generally
- Actually commit that monitoring is a priority…we have a tendency to "do" and assume we are meeting "goals" without going back to see if what we did worked.
- This would require a big shift in thinking to include not just doing but then checking what happened.
- Need department –wide buy-in for monitoring through existing inventory/IFMAP system
- Long-term management plans that include these efforts
- Design control efforts as experimental research projects
- Need common, standardized monitoring protocols (look at NIISS)
- Easy to use tracking system/methodology for monitoring progress of management efforts that can be used across treatments and species
- Monitor spread, impacts, and success of management techniques over multiple growing seasons
- Need to establish long-term monitoring to evaluate effectiveness of treatments

V. Research Needs
Work with other entities

A. Control techniques

- Long-term fire effects research
- Biological Controls: need more research

- Genotype concerns; use of native plants (where from) i.e., Phragmites – need to coordinate with other agencies like MDEQ regulating permitting
- Restoration after invasive species removal; how, with what, local seed sources
- Design control efforts as experimental research projects
- Best recipes for treatments; most current
- Biological control is only real hope for well-established, entrenched species (GM, buck-thorn…)
- When is it ethical to experiment with untreated controls
- Need to establish long-term monitoring to evaluate effectiveness of treatments
- Monitor spread, impacts, and success of management techniques over multiple growing seasons
- How does management of desired communities impact invasives (e.g., fire)
- Need more $$ for biocontrols and more species being researched

B. Invasive species ecology, impacts, uses

- Impact studies – economic and ecological - quantify ecological impacts more strongly
- Document impacts of not controlling invasive species vs. controlling invasives
- Create maps of monitoring/inventory over time – assess population trends (inc. vs dec) and where. Share with all agencies that could leave an impact (Cons. Dist., NRCS, DNR, USFWS, MDOT, etc.)
- Predictive modeling
- Assess economic uses for buckthorn and others (woody biomass for heating, furel, energy source
- Can T&E species adapt to invaders?
- Statewide database of location and status available to all resource mgmt and conservation groups for data input and output
- How do you know of a non-native species that persists at low levels will become invasive - is it in early stages of infestation or will it never take hold at a particular site
- How much survey is needed before deciding on strategy for attack.
- Relationships of invasives and deer herbivory (+/-); how do deer impact invasives and vice versa
- Have any big infestations contracted over time (populations cycling up and down?)

VI. Training Needs

- Train all agency staff – ID, documentation, reporting, ecology, rapid response, mapping
- Train selected staff on long-term control techniques and monitoring
- Train public – recognize, report, prioritize invasive species, awareness; perceptions about plants, land managers, "envirotypes"
- Educate decision-makers – focus on message "if we don't, then who will?"
- Develop invaisve plant Icon
- Develop localized hot lists
- List of contact information for individuals, organizations, weed specific UPIC
- Best prevention, control, restoration practices – most effective controls locally, regionally
- Prioritizing sites for control
- Monitoring
- Make presentations available
- Interagency training
- Tribes desire training
- Forestry consultants
- Provide at employer expense certified pesticide applicator training, if needed to apply herbicides
- Lack of botanical knowledge/ID skills by

Management Agency staff and other decision-makers that do wetlands permit review. Need botany courses
- Field guides with color photos of plants to all field people
- Need regular update training on invasive ID for field foresters to aid in defining locations – they cover a lot of ground doing inventory (fire officers & temp workers too who work in campgrounds and on road projects (spreading ground)
- Fire
- Need training on computer/GPS mapping, GIS/Database/PDR
- Need to PUSH reading – a lot of information is out there, we need to take the time to read/look
- Could work with campground hosts to educate about plants and problem areas
- Pesticide/herbicide applicators – not enough people certified

VII. Education and Outreach

- Target school kids; especially 5-6th graders
- Establish a national Icon similar to smoky the bear
- PR to private land holders
- Cost-share information to private land holders
- Education/outreach through conservation districts
- Make educational presentations available
- Education: consistent message "branding" weed logos, etc.
- Priority develops after something affects a person's time or pocketbook – so let agencies & the public know how they will be affected by doing nothing vs something
- Provide alternative native species lists
- Conduct education and outreach to public, retailers, etc.
- Educate public campground hosts
- Provide field guides and materials to public
- Deliver television news spots

VIII. Funding Needs and Sources

- Build economic case for invasive species work – gather public support and political pressure
- Need stable, long-term funding to be effective – most control projects must be multiple years
- Need consistency in funding for management units, e.g., SWG vs WIP process
- Fund designated point staff for UP and several regional coordinators (E,W,Central), ditto LP
- Fund herbicide purchase, certified applicators, prescribed burns, training, and other control techniques
- Fund seasonal workers, dedicated to invasive species detection, control and monitoring
- Prioritize funding from DNR
- Provide list of funding opportunities and technical assistance to write grants
- Write WIPs to do work but also look at grant opportunities
- Collaborate with other agencies and NGOs to secure funding for coordinated control work and training: EDRR, Mapping, Regional prevention and control; use CWMA for this
- Partner for match
- Network with local volunteer groups, especially land trusts, natural area stewards, native plant groups, youth groups, etc. to help with control
- Can't find willing volunteers
- Develop products (posters, patches, trading cards, etc.) that can be sold

Potential Funding Sources

- SWG
- USDA-WHIP
- USDA-EQUIP
- National Forest Foundation
- National Fish and Wildlife Foundation (cooperative funding through CWMA's)
- National Fish & Wildlife Foundation: Great Lakes Watershed Restoration
- USDA – Natural Resources Conservation Service, Conservation Innovation Grants
- USFWS regional and national funds
- Private Foundations
- Mini-grants for individual projects
- Sportsmen's clubs – will contribute money, time, and passion
- Re-prioritize existing funding sources
- General funds should be used for this
- Fines for regulation of invasive species – money should go to programs

IX. Coordination with other Landowners

- Open communication with land managers across the state and with adjacent states about priorities, action, need, impacts, prevention
- Need DNR/WLD state and regional and local leads
- Consider multiple scale priorities when making management choices
- Participate in Upper Peninsula Invasive Plant Council (UPIC) and other CWMA's
- Who to contact with different agencies
- Dedicate a person and/or position within an agency; preferably more but at least 1
- For "field folks": Coordination = winter activity, NOT April – November
- Coordination with local nurseries too about what not to sell/push!
- In fire fighting, the Great Lakes Forest Fire Compact (GLFFC) coordinates the movement of fire fighting resources between state and provinces. Perhaps this model could be used to coordinate invasive programs if enough priority can be given. Local/Regional scale works
- Conservation districts serve as a gateway to private landowners
- Establish CWMA's – share labor and equipment, eligible for more funding than some agencies
- Landowner contact when infestations are discovered
- Cost-sharing to help private landowners control invasives on private and tribal lands
- Need methods/training for private landowners (more than just a web site)
- Industribal land holders need more assistance
- Statewide contact information
- Expand UPIC listserve to include all members of this group
- Inform, include local agencies/groups when conducting work or when infestations are discovered
- DNR – interdivisional invasive plant committee to coordinate and plan DNR activities and pool resources
- Coordination between agencies, volunteers, landowners, businesses, etc. CWMA
- Don't waste resources duplicating effort.
- Direct resources towards unmet needs and use standards to facilitate sharing and building upon prior work This group should meet periodically to follow-up on issues/challenges identified today
- What is already known/done/available?
- Expand UPIC list serve to include all members of this group

- Inform, include local agencies/groups when conducting work or when infestations are discovered
- DNR – interdivisional invasive plant committee to coordinate and plan DNR activities and pool resources

Values

- Grouse coverts
- Unique areas – barrens dunes high quality hardwoods
- Examine "watchable wildlife" sites for invasives
- Examine any high volume tourist gathering point for invasives (can it become invasive itself?)
- Wild Rice
- Wildlife
- Fish
- Blueberry patch
- Endangered species
- Migratory birds – esp priority species/habitats

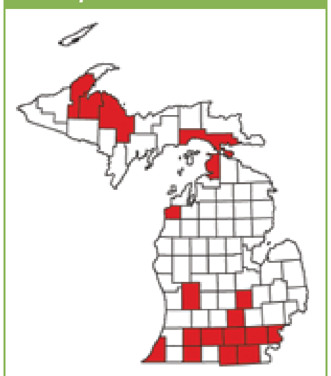
Policy

- Policy needs to be changed for local priorities, e.g. farm bill
- Policies: do no harm – regulate and quality control
- Seed mixes, food plots

Appendix B. County Distribution Maps

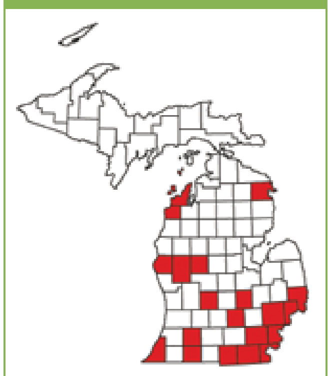
These maps were created primarily from herbarium specimens and are only an approximation of actual distributions. In some cases, species are present in counties where they are not noted. In other cases, they are present only in isolated locations, making them appear to be far more widespread. Updating them is a critical next step

Acer platanoides



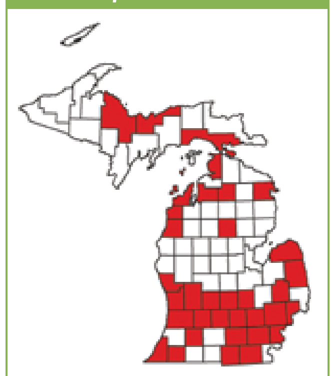
Norway maple

Ailanthus altissima



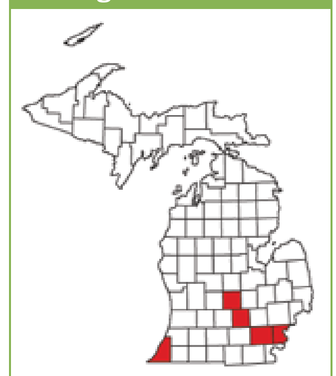
Tree-of-heaven

Alliaria petiolata



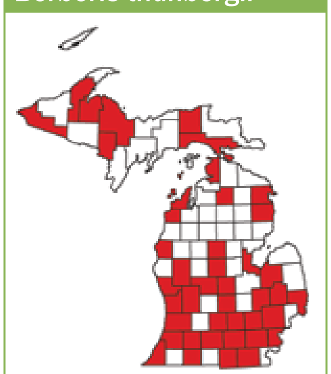
Garlic mustard

Alnus glutinosa



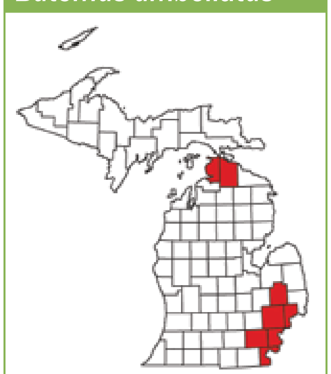
Black alder

Berberis thunbergii



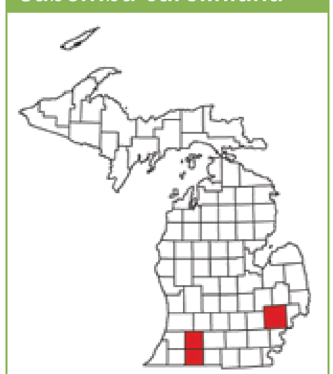
Barberry

Butomus umbellatus



Flowering rush

Cabomba caroliniana

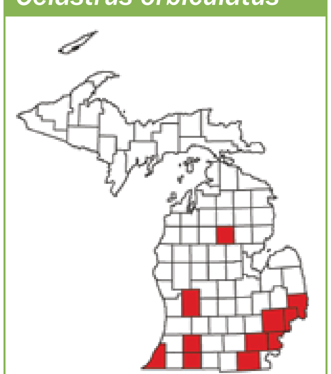


Carolina fanwort

Cardamine impatiens

Narrow-leaf bitter-cress

Celastrus orbiculatus

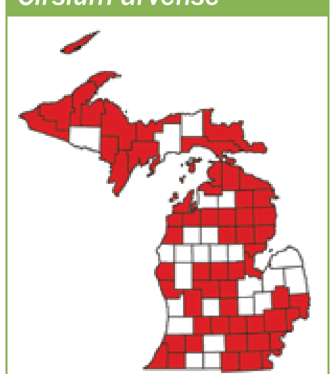


Oriental bittersweet

Centaurea maculosa

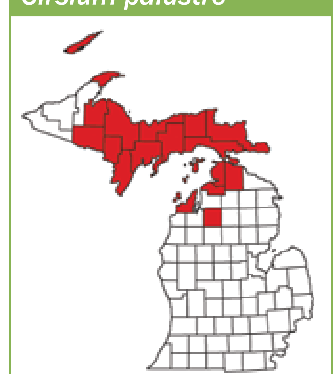
Spotted knapweed

Cirsium arvense



Canada thistle

Cirsium palustre

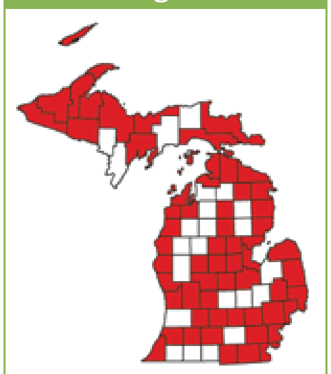


European swamp thistle

Appendix B. County Distribution Maps - continued

These maps were created primarily from herbarium specimens and are only an approximation of actual distributions. In some cases, species are present in counties where they are not noted. In other cases, they are present only in isolated locations, making them appear to be far more widespread. Updating them is a critical next step

Cirsium vulgare

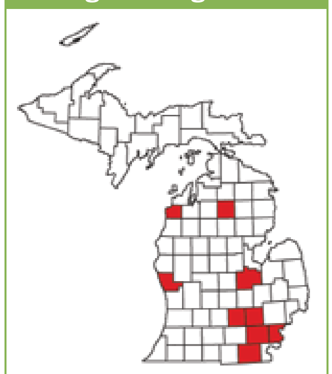


Bull thistle

Eichhornia crassipes

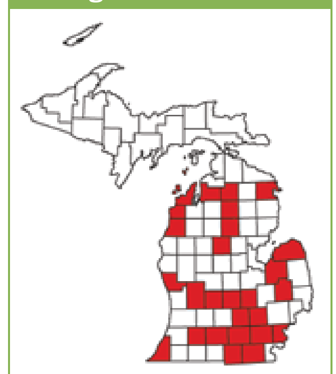
Water hyacinth

Elaeagnus angustifolia



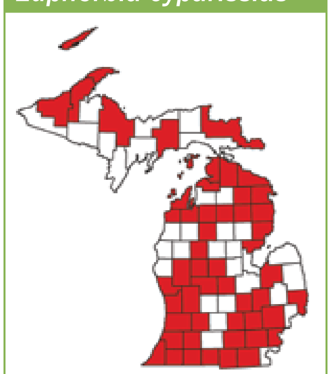
Russian olive

Elaeagnus umbellata



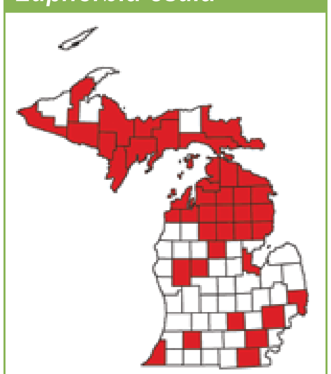
Autumn olive

Euphorbia cyparissias



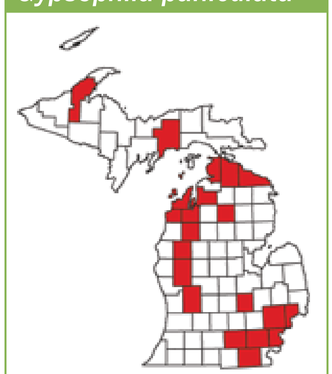
Cypress spurge

Euphorbia esula



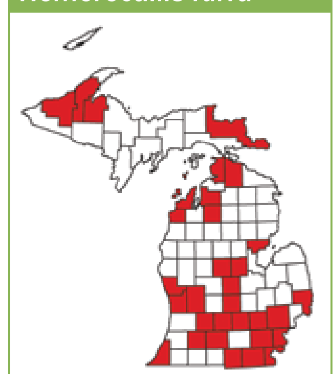
Leafy spurge

Gypsophila paniculata



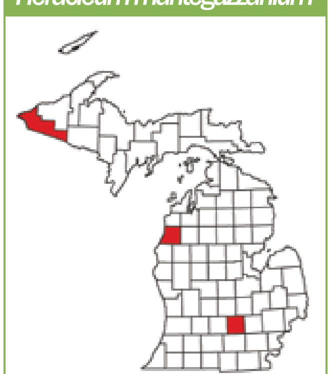
Baby's breath

Hemerocallis fulva



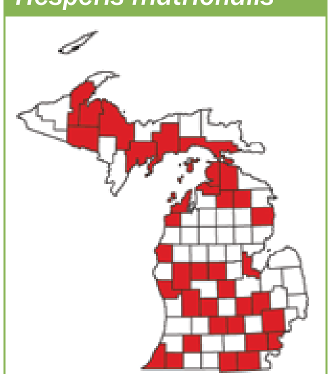
Yellow day-lily

Heracleum mantegazzanium



Giant hogweed

Hesperis matrionalis



Dame's rocket

Hydrocharis morsus-ranae

European frog-bit

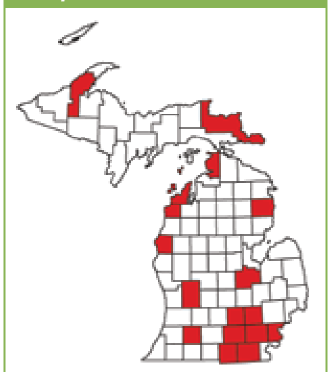
Hypericum perforatum

Common St. Johnswort

Appendix B. County Distribution Maps - continued

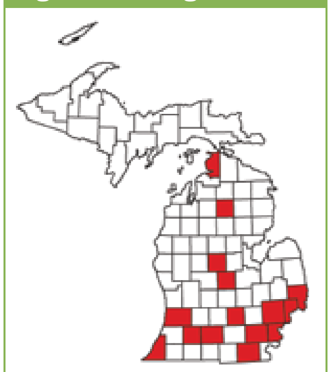
These maps were created primarily from herbarium specimens and are only an approximation of actual distributions. In some cases, species are present in counties where they are not noted. In other cases, they are present only in isolated locations, making them appear to be far more widespread. Updating them is a critical next step

Iris pseudacorus



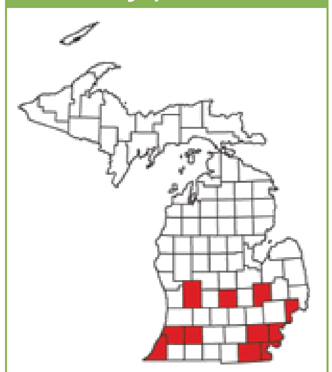
Yellow iris

Ligustrum vulgare



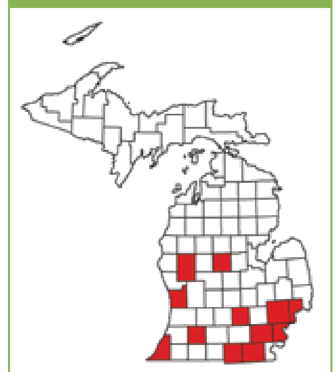
Common privet

Lonicera japonica



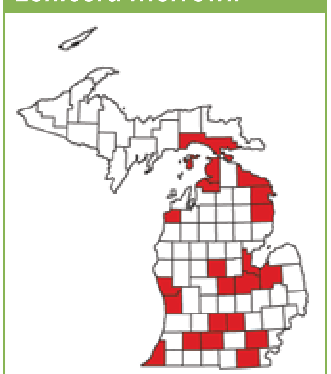
Japanese honeysuckle

Lonicera maackii



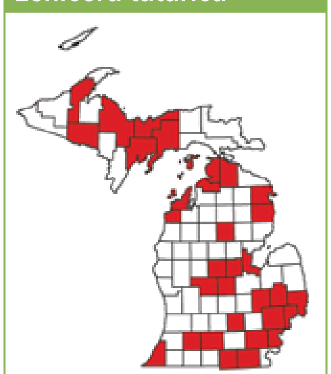
Amur honeysuckle

Lonicera morrowii



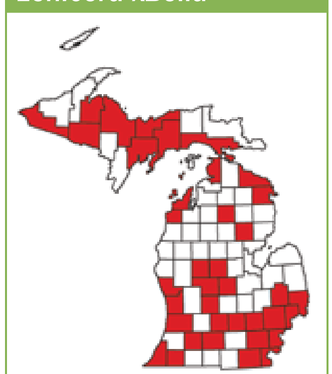
Morrow's honeysuckle

Lonicera tatarica



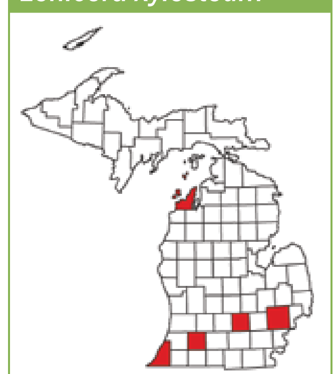
Tatarian honeysuckle

Lonicera xBella



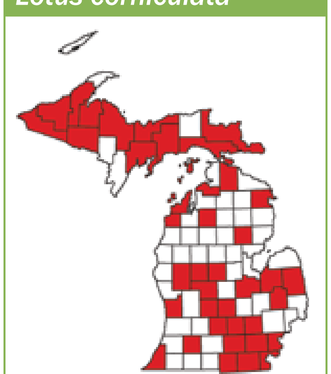
Bell's honeysuckle

Lonicera xylosteum



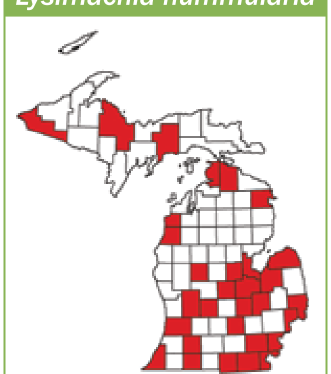
European fly honeysuckle

Lotus corniculata



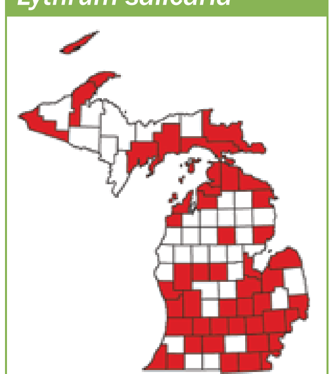
Birdsfoot trefoil

Lysimachia nummularia



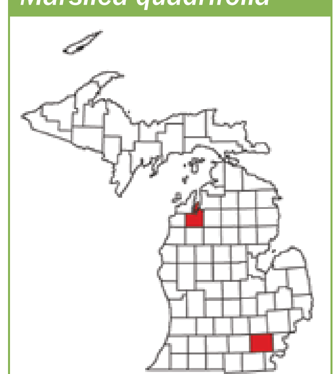
Moneywort

Lythrum salicaria



Purple loosestrife

Marsilea quadrifolia



European waterclover

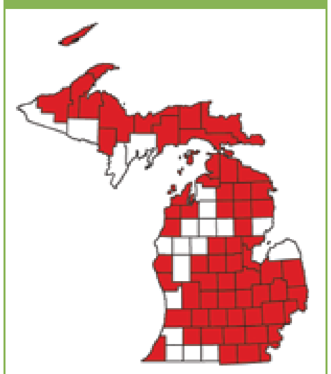
Appendix B. County Distribution Maps - continued

These maps were created primarily from herbarium specimens and are only an approximation of actual distributions. In some cases, species are present in counties where they are not noted. In other cases, they are present only in isolated locations, making them appear to be far more widespread. Updating them is a critical next step

Melilotus alba

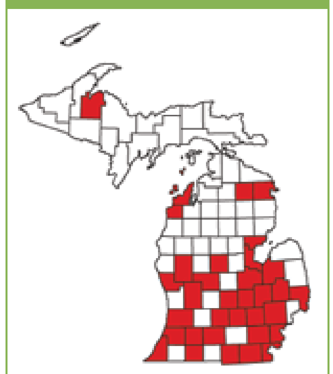
White sweet clover

Melilotus officinalis



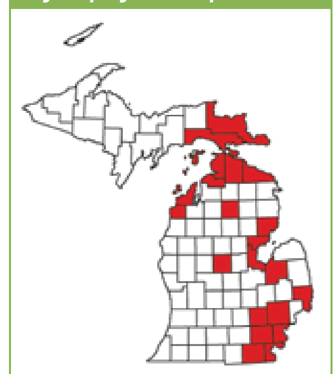
Yellow sweet clover

Morus alba



White mulberry

Myriophyllum spicatum

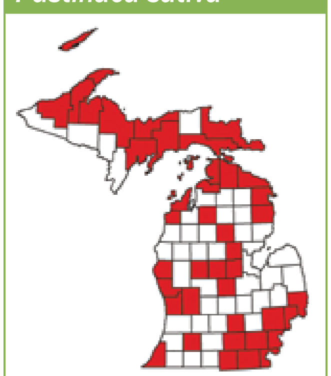


Eurasian water-milfoil

Najas minor

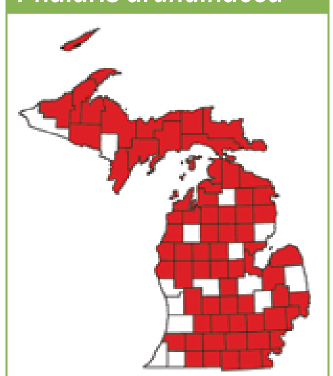
Slender naiad

Pastinaca sativa



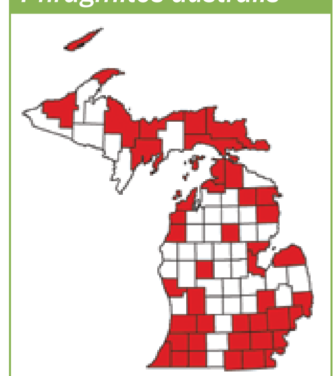
Wild parsnip

Phalaris arundinacea



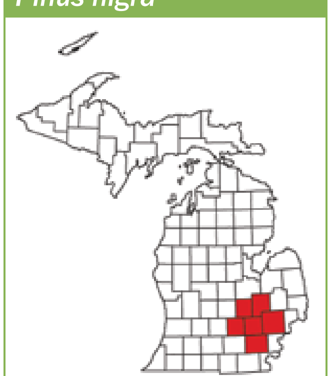
Reed canary grass

Phragmites australis



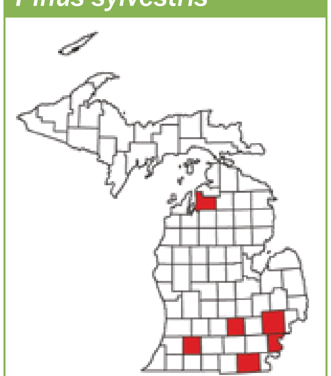
Common reed

Pinus nigra



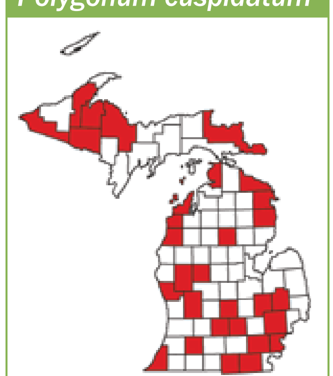
Austrian pine

Pinus sylvestris



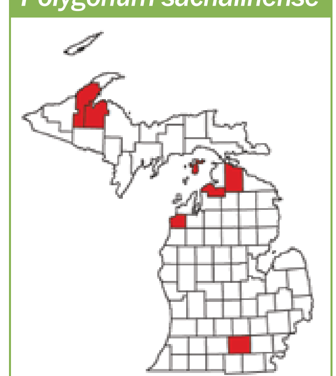
Scotch pine

Polygonum cuspidatum



Japanese knotweed

Polygonum sachalinense

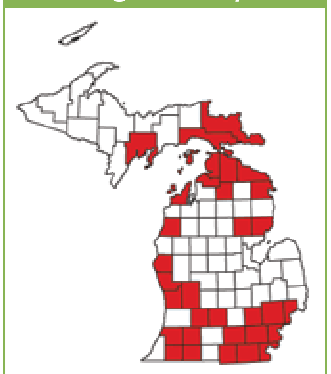


Giant knotweed

Appendix B. County Distribution Maps - continued

These maps were created primarily from herbarium specimens and are only an approximation of actual distributions. In some cases, species are present in counties where they are not noted. In other cases, they are present only in isolated locations, making them appear to be far more widespread. Updating them is a critical next step

Potamogeton crispus

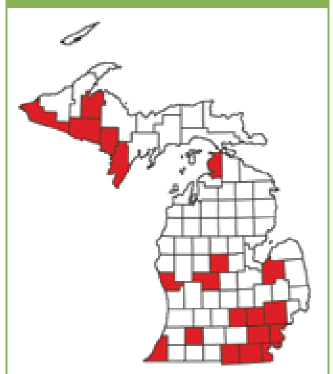


Curly pondweed

Pueria lobata

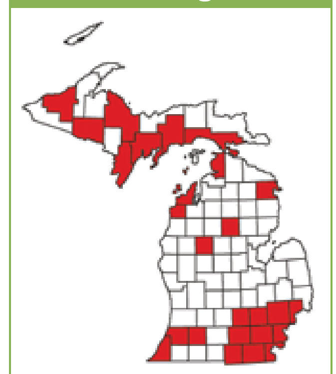
Kudzu

Rhamnus cathartica



Common buckthorn

Rhamnus frangula

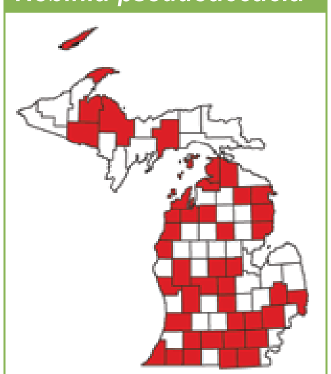


Glossy buckthorn

Rhodotypos scandens

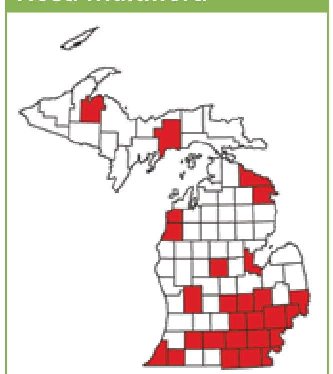
Jetbead

Robinia pseudoaccacia



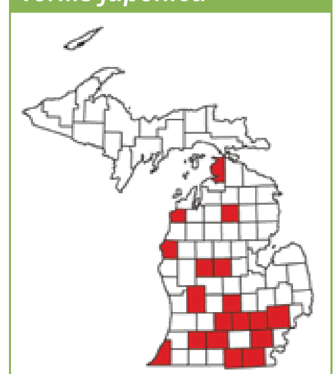
Black locust

Rosa multiflora



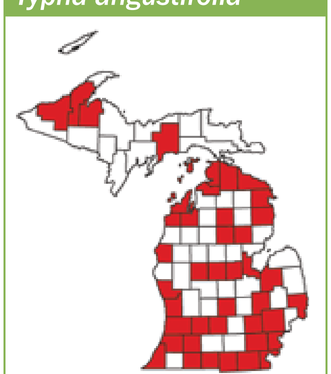
Multiflora rose

Torilis japonica



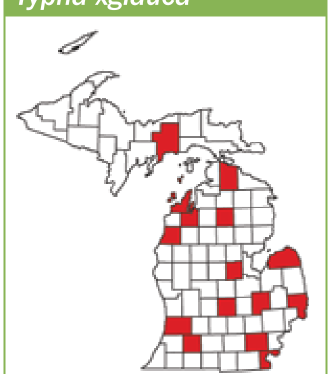
Japanese hedge-parsley

Typha angustifolia



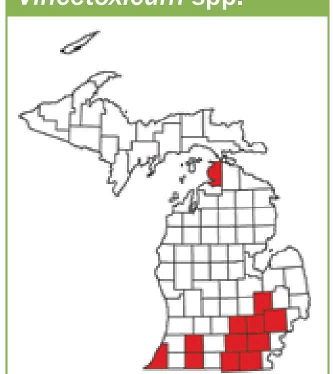
Narrowleaf cattail

Typha xglauca



Hybrid cattail

Vincetoxicum spp.



Swallow-worts

Appendix C. Master List of Invasive Species

Scientific Name	Common Name	Habitat: Wooded Upland	Open upland	Wooded Wetland	Open wetland	Aquatic	Region: SLP	NLP	EUP	WUP	Legal Status: Section 324.41301	Federal Noxious Weed	MDA Noxious Weed
Acer platanoides	Norway maple	■	■				L	I	I	I			
Ailanthus altissima	tree of heaven	■	■				W	I	N	N			
Alliaria petiolota	garlic mustard	■	■	■			W	L	I	I			
Alnus glutinosa	black alder			■	■		L	N	N	N			
Ampelopsis brevipedunculata	porcelain-berry		■				I	N	N	N			
Ampelopsis cordata	heartleaf peppervine		■				I	N	N	N			
Azolla pinnata	water velvet					■	N	N	N	N	R		
Berberis thunbergii	barberry	■	■				W	I	L	L			
Bromus inermis	smooth brome		■				W	L	L	L			
Butomus umbellatus	flowering rush				■	■	L	I	N	N	R		
Cabomba caroliniana	Carolina fanwort					■	I	N	N	N			
Callitriche stagnalis	pond water-starwort					■	N	N	N	N			
Cardamine impatiens	narrow-leaved bitter-cress	■	■				I	N	N	N			
Carduus acanthoides	plumeless thistle		■				I	I	I	N			P
Carduus nutans	musk thistle		■				L	N	I	N			P
Carex acutiformis	European lake sedge				■	■	N	N	N	N			
Celastrus orbiculata	Oriental bittersweet	■	■				W	I	N	N			
Centaurea diffusa	spreading starthistle		■				L	L	I	I			
Centaurea repens	Russian knapweed		■				I	N	N	N			P
Centaurea solstitialis	yellow starthistle		■				I	I	N	N			
Centaurea maculosa	spotted knapweed		■				W	W	W	W			P
Cirsium arvense	Canada thistle		■				W	W	W	W			P
Cirsium palustre	swamp thistle				■		N	I	L	L			
Cirsium vulgare	bull thistle		■				W	W	W	W			P
Convallaria majalis	lily-of-the-valley	■					I	I	I	I			
Coronilla varia	crown vetch		■				W	L	L	L			
Crassula helmsii	Australian stone crop					■	N	N	N	N			
Dipsacus fullonum	common teasel		■				W	I	I	I			
Dipsacus laciniatus	cutleaf teasel		■				W	I	I	I			
Egeria densa	Brazilian water-weed					■	N	N	N	N	P		

I - isolated L - local W - widespread N - not present P - prohibited R - restricted ◆ - on the list

Scientific Name	Common Name	Wooded Upland	Open upland	Wooded Wetland	Open wetland	Aquatic	SLP	NLP	EUP	WUP	Section 324.41301	Federal Noxious Weed	MDA Noxious Weed
		Habitat					Region				Legal Status		
Eichhornia crassipes	water velvet					■	I	N	N	N			
Elaeagnus angustifolia	Russian olive		■				L	N	N	N			
Elaeagnus umbellata	autumn olive	■	■				W	L	L	L			
Epilobium hirsutum	great hairy willow-herb				■		L	I	N	N			
Euphorbia cyparissias	Cypress spurge		■				L	L	L	L			
Euphorbia esula	leafy spurge		■		■		L	W	W	I			P
Galeopsis tetrahit	hemp-nettle	■	■				I	L	W	W			
Glyceria maxima	reed mannagrass				■		N	N	N	N			
Gypsophila paniculatus	baby's breath		■				L	L	I	I			
Hemerocallis fulva	orange day lily	■					I	I	I	I			
Heracleum mantegazzianum	giant hogweed	■	■	■	■		I	N	N	I	P	◆	
Hesperis matronalis	Dame's rocket	■					W	L	L	L			
Humulus japonicus	Japanese hops		■	■	■		I	N	N	N			
Hydrilla verticillata	*Hydrilla*					■	N	N	N	N	P	◆	
Hydrocharis morsus-ranae	European frog-bit					■	I	N	N	N	P		
Hygrophila polysperma	Indian swampweed					■	N	N	N	N			
Hypericum perforatum	common St. John's-wort		■				W	W	W	W			
Iris pseudacorus	yellow flag				■		I	I	N	N	P		
Impatiens glandulifera	Indian balsam				■		N	N	I	I			
Lagarosiphon major	African oxygen weed					■	N	N	N	N	P		
Landoltia punctata	dotted duckweed					■	N	N	N	N			
Lespedeza cuneata	Chinese lespedeza		■				L	I	N	N			
Ligustrum obtusifolium	border privet	■	■				L	I	I	I			
Ligustrum vulgare	privet	■	■				L	N	N	N			
Lonicera japonica	Japanese honeysuckle	■	■				W	I	N	N			
Lonicera maackii	Amur honeysuckle	■	■				W	L	I	N			
Lonicera morrowii	Morrow's honeysuckle	■	■				W	L	L	L			
Lonicera tatarica	Tartarian honeysuckle	■	■				W	L	L	L			
Lonicera Xbella	Bell's honeysuckle	■	■				I	I	N	N			
Lonicera xylosteum	European fly honeysuckle	■	■				W	L	L	L			
Lotus corniculata	birdfoot trefoil		■				L	L	L	L			

I - isolated   L - local   W - widespread   N - not present   P - prohibited   R - restricted   ◆ - on the list

Scientific Name	Common Name	Habitat					Region				Legal Status		
		Wooded Upland	Open upland	Wooded Wetland	Open wetland	Aquatic	SLP	NLP	EUP	WUP	Section 324.41301	Federal Noxious Weed	MDA Noxious Weed
Lysimachia nummularia	moneywort			■	■		I	N	N	I			
Lysimachia vulgaris	golden loosestrife				■		W	W	L	L			
Lythrum salicaria	purple loosestrife				■		W	W	W	W	R		
Marsilea quadrifolia	European water-clover					■	I	I	N	N			
Melilotus alba	white sweet clover		■				W	W	W	W			
Melilotus officinalis	yellow sweet clover		■				I	N	N	N			
Microstegium vimineum	Japanese stilt grass	■					I	N	N	N			
Morus alba	white mulberry	■	■				W	L	N	I			
Myriophyllum aquaticum	parrot feather					■	N	N	N	N	P		
Myriophyllum heterophyllum	variable-leaf watermilfoil					■	W	W	W	W			
Myriophyllum spicatum	Eurasian water milfoil					■	W	W	W	W	R		
Najas minor	lesser naiad					■	I	N	N	N			
Nasturtium officinale	watercress					■	W	W	W	W			
Nelumbo nucifera	sacred lotus					■	N	N	N	N			
Nitellopsis obtusa	starry stonewort					■	L	N	N	N			
Nymphoides peltata	yellow floating heart					■	N	N	N	N	P		
Pastinica sativa	wild parsnip		■		■		L	W	W	L			
Phalaris arundinacea	reed canary grass				■		W	W	W	W			
Phellodendron amurense	Amur cork-tree	■	■				I	N	N	N			
Phragmites australis	common reed				■		W	L	I	I	R		
Pinus nigra	Austrian pine		■				I	N	N	N			
Pinus sylvestris	Scotch pine	■	■				L	I	N	N			
Pistea stratioides	water lettuce					■	I	N	N	N			
Polygonum caespitosum	Oriental lady's thumb				■		I	N	N	I			
Polygonum cuspidatum	Japanese knotweed		■		■		W	I	I	I	P		
Polygonum perfoliatum	mile-a-minute weed		■		■		N	N	N	N			
Polygonum sachalinensis	giant knotweed		■		■		I	I	I	I			
Populus alba	white poplar				■		L	I	I	I			
Populus nigra var. italica	Lombardy poplar		■				I	I	I	I			
Potamogeton crispus	curly pondweed					■	W	W	I	I	R		
Pueraria lobata	Kudzu	■	■				I	I	N	N			

I - isolated L - local W - widespread N - not present P - prohibited R - restricted ◆ - on the list

Scientific Name	Common Name	Wooded Upland	Open upland	Wooded Wetland	Open wetland	Aquatic	SLP	NLP	EUP	WUP	Section 324.41301	Federal Noxious Weed	MDA Noxious Weed
		Habitat					Region				Legal Status		
Pyrus calleryana	Callery pear	■	■				N	N	N	N			
Quercus acutissima	sawtooth oak		■				N	N	N	N			
Ranunculus ficaria	lesser celandine	■		■			I	N	N	N			
Rhamnus cathartica	common buckthorn	■	■				W	L	I	L			
Rhamnus frangula	glossy buckthorn	■	■	■	■		W	W	W	W			
Rhodotypos scandens	black jetbead	■					I	N	N	N			
Robinia hispida	bristly locust		■				I	I	N	I			
Robinia pseudoacacia	black locust	■	■				W	L	I	I			
Rorippa microphylla	one-row yellowcress				■	■	N	N	N	N			
Rorippa nasturtium-aquaticum	watercress				■	■	N	N	N	N			
Rosa multiflora	multiflora rose	■	■				W	W	I	I			
Salvinia spp.	Giant Salvinia					■	N	N	N	N	P	◆	
Saponaria officinalis	bouncing bet	■	■	■	■		W	W	W	W			
Silene vulgaris	bladder campion		■		■		W	W	W	W			
Solanum dulcamara	bittersweet nightshade			■	■		W	W	W	W			
Stellaria media	common chickweed	■	■				W	W	L	L			
Tanacetum vulgare	common tansy		■				I	I	L	W			
Torilis arvensis	field hedge-parsley		■				N	N	N	N			
Torilis japonica	Japanese hedge-parsley	■	■				W	W	L	L			
Trapa natans	water chestnut					■	N	N	N	N	P		
Typha angustifolia	narrow-leaved cat-tail				■		W	W	L	L			
Typha Xglauca	hybrid cat-tail				■		W	W	L	L			
Verbascum thapsus	mullein		■				L	L	L	L			
Veronica beccabunga var. beccabunga	European brooklime		■		■	■	N	N	L	N			
Viburnum opulus	European highbush cranberry	■	■				L	L	N	L			
Vicia villosa	cow vetch		■				W	W	W	W			
Vinca minor	periwinkle	■	■				L	I	I	I			
Vincetoxicum nigrum	black swallowwort	■	■				L	I	N	N			
Vincetoxicum rossicum	pale swallowwort	■	■				L	N	N	N			

I - isolated   L - local   W - widespread   N - not present   P - prohibited   R - restricted   ◆ - on the list

Appendix D. Annotated Bibliography

Benoit, LK. 1999. Impact of the spread of Phragmites on the distribution of birds in Connecticut tidal marshes. Wetlands, 19(1):194-208.

> Dense monocultures of Phragmites australis (common reed) have been rapidly expanding in Connecticut's tidal wetlands at the expense of cordgrass (Spartina spp.) and cattail (Typha spp.). Bird and vegetation surveys in 40 salt and brackish marshes showed that there were significantly fewer species of birds and state-listed species in Phragmites-dominated wetlands that in short-grass marshes. Seaside Sparrow, Saltmarsh Sharp-tailed Sparrow, and Willet, three marsh specialists adapted to nesting in short graminoids, had low frequencies in plots dominated by Phragmites. Marsh Wren and Swamp Sparrow, however, are marsh specialists that prefer tall, reedy vegetation, and both species had significantly higher densities at sites with more Phragmites or cattail. Although the bird communities of cattail sites and Phragmites sites were similar, the abundance of Virginia Rails was positively correlated with percent cover of cattail but not Phragmites. The extent of pools was positively related to bird species richness in short-grass meadows but not in Phragmites plots. In Phragmites-dominated wetlands, the height and density of reed stands may inhibit bird use of any pools that are present. Muskrats create pools that may enhance bird species richness, but populations of this mammal have dwindled during the same time period that Phragmites increased in Connecticut's marshes. Although a few species may benefit from reed invasion, it has a negative impact marsh bird species that have already declined. These findings support the continued need for marsh restoration and the control of common reed.

Borgmann, K. L. and A. D. Rodewald (2004). "Nest predation in an urbanizing landscape: the role of exotic shrubs." Ecological Applications 14(6): 1757-1765.

> Researchers examined whether the use of exotic shrubs (Lonicera spp. and Rosa multiflora Thumb.) affected predation in Cardinal (Cardinalis cardinalis) and American Robin (Turdus migratorius) nests along a rural-urban gradient. The effect of nest substrate varied with the landscape matrix, such that nests in exotic shrubs in urbanizing landscapes were twice as likely to be depredated as nests in native substrates, irrespective of distance from the edge. Artificial nests placed in exotic shrubs in rural landscapes also suffered higher rates of nest failure than artificial nests in native substrates. Daily mortality rates were greater for nests in exotic shrubs. Researchers concluded that exotic shrubs can reduce nesting success of forest birds and may cause increased nest failure in urbanizing landscapes.

Burke, D. J., 2008. Effects of Alliaria petiolata (garlic mustard; Brassicaceae) on mycorrhizal colonization and community structure in three herbaceous plants in a mixed deciduous forest. American Journal of Botany, 95:1416-1425.

> Herbaceous plant species are important components of forest ecosystems, and their persistence in forests may be affected by invasive plant species that reduce mycorrhizal colonization of plant roots. I examined the effect of the invasive plant Alliaria petiolata on arbuscular mycorrhizal fungi (AMF) colonizing the roots of three forest plant species. AMF root colonization and community structure was examined from plants that were growing either in the absence or presence of Alliaria under natural forest conditions. AMF root colonization varied among the plant species but was not significantly affected by Alliaria. With molecular methods, 12 different taxa of AMF could be distinguished among the root samples, and these taxa belonged to the genera Acaulospora and Glomus, with Glomus dominating AMF communities. There were significant differences between the community of AMF colonizing roots of Maianthemum racemosum and Trillium grandiflorum, but only AMF communities of Maianthemum roots were significantly affected by Alliaria. Indicator species analysis found that an Acaulospora

species type was a significant indicator of Maianthemum plants grown in the absence of Alliaria. These results suggest invasive plants like Alliaria may selectively suppress AMF fungi, and this suppression can affect AMF communities colonizing the roots of some native plant species.

Collias NE, Collias EC. 1963. Selective feeding by wild ducklings of different species. Wilson Bulletin, 75:6–14.

Provides and oerview of duckling feeding habits, food types and the invertebrate species associated with a variety of plants, including *Phragmites australis*.

DiTomaso, J.M., 2000. Invasive weeds in rangelands: Species, impacts, and management. Weed Science, Vol. 48:2:255-26.

Rangeland and pastures comprise about 42% of the total land area of the United States. About three-quarters of all domestic livestock depend upon grazing lands for survival. Many ranges have had domestic stock grazing for more than 100 years and, as a result, the plant composition has changed greatly from the original ecosystems. Western rangelands previously dominated by perennial bunchgrasses have been converted, primarily through overgrazing, to annual grasslands that are susceptible to invasion by introduced dicots. Today there are more than 300 rangeland weeds in the United States. Some of the most problematic include Bromus tectorum, Euphorbia esula, Centaurea solstitialis, C. diffusa, C. maculosa, and a number of other Centaurea species. In total, weeds in rangeland cause an estimated loss of $2 billion annually in the United States, which is more than all other pests combined. They impact the livestock industry by lowering yield and quality of forage, interfering with grazing, poisoning animals, increasing costs of managing and producing livestock, and reducing land value. They also impact wildlife habitat and forage, deplete soil and water resources, and reduce plant and animal diversity. Numerous mechanical and cultural control options have been developed to manage noxious rangeland weeds, including mowing, prescribed burning, timely grazing, and perennial grass reseeding or interseeding. In addition, several herbicides are registered for use on rangelands and most biological control programs focus on noxious rangeland weed control. Successful management of noxious weeds on rangeland will require the development of a long-term strategic plan incorporating prevention programs, education materials and activities, and economical and sustainable multi-year integrated approaches that improve degraded rangeland communities, enhance the utility of the ecosystem, and prevent reinvasion or encroachment by other noxious weed species.

Fitter, A.H., 2005. Darkness visible: reflections on underground ecology. Journal of Ecology, 93:231-243.

1 Soil science and ecology have developed independently, making it difficult for ecologists to contribute to urgent current debates on the destruction of the global soil resource and its key role in the global carbon cycle. Soils are believed to be exceptionally biodiverse parts of ecosystems, a view confirmed by recent data from the UK Soil Biodiversity Programme at Sourhope, Scotland, where high diversity was a characteristic of small organisms, but not of larger ones. Explaining this difference requires knowledge that we currently lack about the basic biology and biogeography of micro-organisms.

2 It seems inherently plausible that the high levels of biological diversity in soil play some part in determining the ability of soils to undertake ecosystem-level processes, such as carbon and mineral cycling. However, we lack conceptual models to address this issue, and debate about the role of biodiversity in ecosystem processes has centred around the concept of functional redundancy, and has consequently been largely semantic. More precise construction of our experimental questions is needed to advance understanding.

3 These issues are well illustrated by the fungi that form arbuscular mycorrhizas, the Glomeromycota. This ancient symbiosis of plants and fungi is responsible for phosphate uptake in most land plants, and the phylum is generally held to be species-poor and nonspecific, with most members readily colonizing any plant species. Molecular techniques have shown both those assumptions to be unsafe, raising questions about what factors have promoted diversification in these fungi. One source of this genetic diversity may be functional diversity.

4 Specificity of the mycorrhizal interaction between plants and fungi would have important ecosystem consequences. One example would be in the control of invasiveness in introduced plant species: surprisingly, naturalized plant species in Britain are disproportionately from mycorrhizal families, suggesting that these fungi may play a role in assisting invasion.

5 What emerges from an attempt to relate biodiversity and ecosystem processes in soil is our extraordinary ignorance about the organisms involved. There are fundamental questions that are now answerable with new techniques and sufficient will, such as how biodiverse are natural soils? Do microbes have biogeography? Are there rare or even endangered microbes?

Flanders, A. A., W. P. Kuvlesky Jr, et al. (2006). "Effects of invasive exotic grasses on south Texas rangeland breeding birds." The Auk 123(1): 171-182.

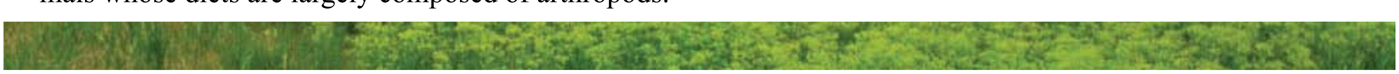
Researchers compared the abundance and species richness of breeding birds, native flora and arthropods South Texas rangeland plots dominated by native grasses and plants dominated by two exotic grasses, Lehmann lovegrass (Eragrostis lehmaniana) and buffelgrass (Cenchrus ciliaris). Shrub canopy, cover, bare ground and vegetation height measurements were similar on all plots. Overall bird abundance was 32 percent higher on native-grass plots, and some species such as Lark Sparrows (Chondestes grammacus) were 73 percent more abundant. Arthropod abundance was 60 percent higher the sampled native grass pot. Unsurprisingly, native grass and forb cover and (plant) species richness were higher on native-grass sites

Franklin, T., J. Asher, et al. (1999). "Policy News: Invasion of the Aliens: Exotic Plants Impact Wildlife." Wildlife Society Bulletin 27(3): 873-875.

Useful overview of examples and challenges.

Gerber, E., C. Krebs, G. Murrell, M. Moretti, R. Rocklin, U. Schaffner, (2008). "Exotic invasive knotweeds (Fallopia spp.) negatively affect plant and vertebrate assemblages in European riparian habitats." Biological Conservation 141(2008):646-654.

In a European study, researchers looked at whether plant species richness and invertebrate assemblages in European riparian habitats invaded by exotic knotweeds differed from those found in native grassland- or bush-dominated riparian habitats, which are both potentially threatened by knotweed invasion. They found that riparian habitats invaded by knotweeds support lower numbers of plant species and lower overall abundance and morphospecies richness of invertebrates, compared to native grassland-dominated and bush-dominated habitats. Total invertebrate abundance and morphospecies richness in knotweed-invaded riparian habitats were correlated with native plant species richness, suggesting that there is a link between the replacement of native plant species by exotic knotweed species and the reduction in overall invertebrate abundance and morphospecies richness. Moreover, biomass of invertebrates sampled in grassland and bush-dominated habitats was almost twice as high as that in knotweed -invaded habitats. Large-scale invasion by exotic knotweed species is therefore likely to seriously affect biodiversity and reduce the quality of riparian ecosystems for amphibians, reptiles, birds and mammals whose diets are largely composed of arthropods.



Ghazoul, J. (2002). “Flowers at the front line of invasion?” Ecological Entomology 27(5): 638-640.

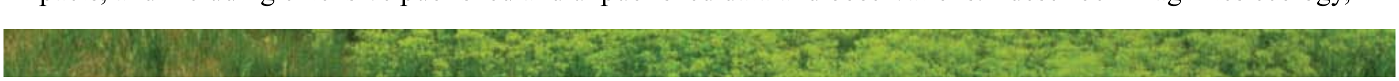
“From the perspective of pollination and seed production, usurpation of pollinators by resource-rich alien plants ensures that alien seed production is favoured over that of native plant species. Coupled with the prolonged flowering period of many aliens, promoting a more or less discontinuous seed rain (and therefore attracting seed dispersers), elevated seed set of aliens together with depressed native seed production may facilitate and accelerate the spread of aliens into new environments. Such a scenario might entail no more than a shift in the foraging behaviour of pollinators, a change that is often overlooked by observers of community change, who tend to focus on the numerical composition of the fauna.”

Greipsson, S. and DiTommaso A., 2006. Invasive Non-native Plants Alter the Occurrence of Arbuscular Mycorrhizal Fungi and Benefit from This Association. Restoration Ecology, 24(4): 236.

We investigated the influence of three aggressive non-native invasive plants (pale swallowwort [Vincetoxicum rossicum], kudzu [Pueraria lobata], and Chinese privet [Ligustrum sinense]) on arbuscular mycorrhizal fungi (AMF). Our findings from central New York and southeastern Alabama forest habitats confirm that each species formed symbiotic associations withnative AMF populations. Mycorrhizal dependency of kudzu was high when grown in invaded (85 percent) and non-invaded (83 percent) soil. The results indicate that invasion into new areas by non-native plant species may alter the occurrence of AMF in the resident soil. Evidence for a possible alteration in the AMF community was obtained largely from a Mycorrhiza Infection Potential bioassay. The bioassay indicated that root colonization levels by AMF of bait plants grown in soil collected from areas where the non-native plants formed pure stands were in general significantly greater than root colonization levels in soils collected from adjacent areas where the invasive plants were not present. Furthermore, the number of AMF spores in soil collected from areas invaded by pale swallow-wort was significantly higher than for nearby non-invaded soil. High colonization levels of pale swallow-wort roots with hyphae were observed during most of the growing season. The presence of arbuscules in pale swallow-wort roots was most evident in July and corresponds with the pre-flowering period of this species.

Kiviat, E., 2006. Phragmites Management Sourcebook for the Tidal Hudson River. Report to the Hudson River Foundation. Annandale, NY.

Phragmites australis (common reed) is an invasive marsh plant spreading in many wetlands on and near the tidal Hudson River. Phragmites is generally considered a pest with low value to wildlife and threatening rare plants, but scientific documentation is ambivalent. Some organisms are favored by Phragmites invasion and some are not. Phragmites appears to have considerable value for water quality amelioration and soil stabilization. Ecological functions of Phragmites vary greatly depending on site and stand factors. Important site factors include depth and duration of flooding, salinity, soil organic matter content, and microtopography; important stand factors include Phragmites height, density, dominance, prevalence of inflorescences (tassels), vine loads, presence of trees or shrubs, stand size, and interspersion of Phragmites patches with other plant communities. Phragmites is often encouraged by, and a symptom of, underlying problems, such as siltation, nutrient loading, and hydrological alteration. Yet Phragmites does not necessarily indicate poor habitat quality. Many restoration and management projects seek to remove Phragmites despite poor understanding of its ecology, the nontarget impacts of removal, and the sustainability of alternate species. I conducted a review and synthesis of information pertinent to the ecology and management of Phragmites on the Hudson River estuary and in nearby areas. This synthesis is unique in focusing on the Hudson River, considering a wide taxonomic and functional range of Phragmites impacts, and including extensive published and unpublished data and observations. I describe Phragmites ecology,



address management issues on the Hudson, outline management techniques and their nontarget impacts, and suggest how research needs can be defined. Depending on management goals, site and stand factors, the surrounding landscape, and the local biota, it may be appropriate to take no action, remove a Phragmites stand, or alter the stand to change its habitat functions and ecosystem services. An explicit and documented decision-making process should be used to justify decisions and acquire information about management outcomes that can inform subsequent management.

Lacey, J. R., C. B. Marlow, et al. 1989. “Influence of spotted knapweed (Centaurea maculosa) on surface runoff and sediment yield.” Weed Technology 3: 627-631.

Surface runoff and sediment yield under simulated condition were compared on paired plots planted with bunchgrass (Agropyron spicatum) and spotted knotweed (Centaurea maculosa). Bunchgrass plots Surface runoff from grass-dominated sites ranged from 3-49 percent of total water applied, averaging 23 percent. On knotweed-dominated sites, runoff ranged from 1-67 percent of total volume, averaging 36 percent.

Lloyd, J.D. and T.E. Martin (2005). “Reproductive Success of Chestnut-collored longspurs in native and exotic grassland.” The Condor 107(2): 363-374.

Population declines in grassland birds have continued in relatively intact prairie systems. To look at potential habitat-specific causes, researchers compared the reproductive success of Chestnut-collared Longspurs (Calcarius ornatus) in patches of native prairie and patches of crested wheatgrass (Agropyron cristatum), an introduced species. In both habitat types daily nest survival declined from egg laying to fledging but nests with larger clutch sizes had a higher survival rate. The odds of a given nest surviving any single day were 17 percent lower, and nestlings grew more slowly and had a smaller final weight on wheatgrass sites. In spite of the reduced reproductive success, Chestnut-collared Longspurs did not appear to prefer nesting in native prairie.

Lutgen, E. R. and M.C. Rillig (2004). “Influence of spotted knapweed (Centaurea maculosa) management treatments on arbuscular mycorrhizae and soil aggregation.” Weed Science 52(1): 172-177.

This study compared soils from spotted knapweed–infested areas with areas where spotted knapweed is being managed using several herbicides and mechanical treatments. Although the study focused on soil aggregate water stability, a common measure of soil structure, rather than mycorrhizal activityThis study has shown that spotted knapweed invasion has a negative effect on parameters associated with soil structure, as shown by a reduction in glomalin concentrations and hyphal length in untreated areas with a high density of this weed compared with managed areas with low spotted knapweed density.

Researchers measured concentrations of glomalin, a glycoprotein produced by arbuscular mycorrhizal fungi (AMF), that is correlated with soil aggregate stability, AMF hyphal length, and percent water-stable aggregates (WSA) in soils from managed and unmanaged areas. Areas with high knapweed density (unmanaged areas) generally had lower glomalin concentrations and AMF hyphal lengths compared with areas receiving chemical and combined mechanical–chemical management treatments. Total glomalin was significantly negatively correlated with percent knapweed cover. However, WSA was high (70 to 80%) in soils from all management treatments and was not affected by knapweed cover. Our results suggest that sp otted knapweed does not have negative effects on soil quality from our study site, likely because of the high aggregate stability of the soils in the area. However, Centaurea maculosa may have negative effects on soil quality in soils with lower aggregate stability.

Maerz, J.C., B. Blossey and V. Nuzzo, (2005). Green frogs show reduced foraging success in habitat invaded by Japanese knotweed, Biodiversity and Conservation 14 (2005), pp. 2901–2911.

Researchers investigated plant community changes in two old fields invaded by Japanese knotweed (Fallopia japonica) and the foraging success of Green frogs (Rana clamitans) in invaded and non-invaded portions of those fields. There were significant changes in vegetation structure and composition associated with Japanese knotweed invasion. Diverse assemblages of native plants that covered non-invaded plots were absent from areas invaded by Japanese knotweed. There was also a significant change in vegetation architecture between invaded and non-invaded habitats. Change in frog mass declined significantly along transects, with most frogs in non-invaded plots gaining mass and no frogs in invaded plots gaining mass. Most frogs from non-invaded plots but only two from invaded plots defecated shortly after removal from foraging buckets (verification of recent feeding). Researchers hypothesized that Japanese knotweed invasions degrade terrestrial habitat quality for frogs by indirectly reducing arthropod abundance. Non-native plant invasions may be another factor contributing to amphibian population declines.

Memmott 2002 Integration of alien plants into a native flower-polinator visitation web." Proceedings of the Royal Society:B Biological Sciences 269(1508): 2395-2399.

Introduced alien species influence many ecosystem services, including pollination of plants by animals. We extend the scope of recent 'single species' studies by analysing how alien plant species integrate themselves into a native flower visitation web. Historical records for a community in central USA show that 456 plant species received visits from 1429 insect and 1 hummingbird species, yielding 15 265 unique interactions. Aliens comprised 12.3% of all plant species, whereas only a few insects were alien. On average, the flowers of alien plants were visited by significantly fewer animal species than those of native plants. Most of these visitors were generalists, visiting many other plant species. The web of interactions between flowers and visitors was less richly connected for alien plants than for natives; nonetheless, aliens were well integrated into the native web. Because most visitors appear to be pollinators, this integration implies possible competitive and facilitative interactions between native and alien plants, mediated through animal visitors to flowers.

Memmott, J. P. G. Craze, et al. (2007). "Global warming and the disruption of plant-pollinator interactions." Ecology Letters 10(8): 710-717.

Anthropogenic climate change is widely expected to drive species extinct by hampering individual survival and reproduction, by reducing the amount and accessibility of suitable habitat, or by eliminating other organisms that are essential to the species in question. Less well appreciated is the likelihood that climate change will directly disrupt or eliminate mutually beneficial (mutualistic) ecological interactions between species even before extinctions occur. We explored the potential disruption of a ubiquitous mutualistic interaction of terrestrial habitats, that between plants and their animal pollinators, via climate change. We used a highly resolved empirical network of interactions between 1420 pollinator and 429 plant species to simulate consequences of the phenological shifts that can be expected with a doubling of atmospheric CO_2. Depending on model assumptions, phenological shifts reduced the floral resources available to 17–50% of all pollinator species, causing as much as half of the ancestral activity period of the animals to fall at times when no food plants were available. Reduced overlap between plants and pollinators also decreased diet breadth of the pollinators. The predicted result of these disruptions is the extinction of pollinators, plants and their crucial interactions.

Meyer, S. W. (2003). Comparative use of Phragmites australis and other habitats by birds, amphibians, and small

mammals at Long Point, Ontario, M. Sc. Thesis, University of Western Ontario, London, Ontario. Accessed online 1/09 at: http://www.deltawaterfowl.org/research/theses/Meyer_Shawn.pdf

Meyer surveyed birds, amphibians, and small mammals in various stand sizes of Phragmites, Typha spp., and marsh meadow at Long Point, Lake Erie, Ontario. Avian point counts showed that stands of exotic Phragmites had fewer rails, waterfowl, and breeding Swamp Sparrows (Melospiza georgiana) than did stands of Typha or marsh meadow. Large stands of exotic Phragmites, however, had a high abundance of Red-winged Blackbirds (Agelaius phoeniceus) and Common Yellowthroats (Geothlypis trichas) and provided habitat for Least Bitterns (Ixobrychus exilis), swallows (Family Hirundinidae), juvenile Swamp Sparrows, and Marsh Wrens (Cistothorus palustris). Use of exotic Phragmites by Virginia (Rallus limicola) and Sora Rails (Porzana carolina) was limited to stand edges. Stands of exotic Phragmites did not affect migrating birds and may provide winter shelter for Black-capped Chickadees (Poecile atricapillus), American Tree Sparrows (Spizella arborea), and Dark-eyed Juncos (Junco hyemalis). Pitfall traps showed that Fowler's Toads (Bufo woodhousii fowleri) did not use large stands of exotic Phragmites and use by Northern Leopard Frogs (Rana pipiens) was limited. Small stands of exotic Phragmites had more amphibians [primarily juvenile toads (Bufo spp.)] than did small stands of Typha and marsh meadow in mid-summer. Interior traps in large stands of exotic Phragmites had fewer amphibians than did edge traps in Phragmites and traps in Typha and marsh meadow. Species richness of amphibians, however, was similar in all three habitats. Overall, all small stands, regardless of habitat type, had more individuals and higher species richness of amphibians than did large stands. Although only four species of small mammals were captured, large stands of exotic Phragmites had higher abundance and species richness of small mammals than did large stands of Typha and marsh meadow.

Morales, C. L. and M.A. Aizen (2006). "Invasive mutualisms and the structure of plant-polinator interactions in the temperate forests of north-west Patagonia, Argentina." Journal of Ecology 94(1): 171-180

1 Alien species may form plant–animal mutualistic complexes that contribute to their invasive potential. Using multivariate techniques, we examined the structure of a plant–pollinator web comprising both alien and native plants and flower visitors in the temperate forests of north-west Patagonia, Argentina. Our main objective was to assess whether plant species origin (alien or native) influences the composition of flower visitor assemblages. We also examined the influence of other potential confounding intrinsic factors such as flower symmetry and colour, and extrinsic factors such as flowering time, site and habitat disturbance. 2 Flowers of alien and native plant species were visited by a similar number of species and proportion of insects from different orders, but the composition of the assemblages of flower-visiting species differed between alien and native plants. 3 The influence of plant species origin on the composition of flower visitor assemblages persisted after accounting for other significant factors such as flowering time, bearing red corollas, and habitat disturbance. This influence was at least in part determined by the fact that alien flower visitors were more closely associated with alien plants than with native plants. The main native flower visitors were, on average, equally associated with native and alien plant species. 4 In spite of representing a minor fraction of total species richness (3.6% of all species), alien flower visitors accounted for > 20% of all individuals recorded on flowers. Thus, their high abundance could have a significant impact in terms of pollination. 5 The mutualistic web of alien plants and flower-visiting insects is well integrated into the overall community-wide pollination web. However, in addition to their use of the native biota, invasive plants and flower visitors may benefit from differential interactions with their alien partners. The existence of these invader complexes could contribute to the spread of aliens into novel environments.

Ortega, Y. K., K. S. McKelvey, et al. (2006). "Invasion of an exotic forb impacts reproductive success and site fidelity

of a migratory songbird." Oecologia 149(2):349-351.

Although exotic plant invasions threaten natural systems worldwide, we know little about the speciWc ecological impacts of invaders, including the magnitude of eVects and underlying mechanisms. Exotic plants are likely to impact higher trophic levels when they overrun native plant communities, aVecting habitat quality for breeding songbirds by altering food availability and/or nest predation levels. We studied chipping sparrows (Spizella passerina) breeding in savannas that were either dominated by native vegetation or invaded by spotted knapweed (Centaurea maculosa), an exotic forb that substantially reduces diversity and abundance of native herbaceous plant species. Chipping sparrows primarily nest in trees but forage on the ground, consuming seeds and arthropods. We found that predation rates did not diVer between nests at knapweed and native sites. However, initiation of Wrst nests was delayed at knapweed versus native sites, an eVect frequently associated with low food availability. Our seasonal fecundity model indicated that breeding delays could translate to diminished fecundity, including dramatic declines in the incidence of double brooding. Site Wdelity of breeding adults was also substantially reduced in knapweed compared to native habitats, as measured by return rates and shifts in territory locations between years. Declines in reproductive success and site fidelity were greater for yearling versus older birds, and knapweed invasion appeared to exacerbate diVerences between age classes. In addition, grasshoppers, which represent an important prey resource, were substantially reduced in knapweed versus native habitats. Our results strongly suggest that knapweed invasion can impact chipping sparrow populations by reducing food availability. Food chain eVects may be an important mechanism by which strong plant invaders impact songbirds and other consumers.

Paxton, B. J. (2006). "Potential Impact of Common Reed Expansion on Threatened High-marsh Bird Communities on the Seaside: Assessment of Phragmites Invasion of High Marsh Habitats. Center for Conservation Biology Technical Report Series, CCBTR-06-17. College of Willliam and Mary, Williamsburg, VA. 9pp.

Rice P. M., Toney, J. C., Bedunah, D. J., and Carlson, C. E., 1997. Elk winter forage enhancement by herbicide control of spotted knapweed Wildlife Society Bulletin, 25(3):627-633

Spotted knapweed (Centaurea maculosa) is an exotic forb that aggressively invades grassland and early-successional forest sites in the Northern Rocky Mountains of the United States and Canada. Reduced vigor of native bunchgrass populations on spotted knapweed-infested win- ter elk ranges is potentially decreasing the forage value of these sites. We analyzed standing crop data collected 1 and 3 years after spraying for spotted knapweed control at 3 experi- mental sites in western Montana. Plant species biomass estimates were scaled by numerical indices quantifying the selection behavior of elk on winter range, and then summed over all species in each experimental plot. By the third year after spraying, herbicide plots averaged 47% greater ($P< 0.05$) elk winter forage than the no-spray check plots. Implications for management of elk winter range sites in the Northern Rockies are discussed.

Roberts KJ, Anderson RC (2001) Effect of garlic mustard [Alliaria petiolata (Beib. Cavara & Grande)] extracts on plants and arbuscular mycorrhizal (AM) fungi. Am Midl Nat 146: 146–152.

Researchers examined the effects of garlic mustard leachates on the germination of arbuscular mycorrhizal (AM) fungal spores, colonization by plant roots by AM fungi and germination and root growth of monocot and dicot plants under laboratory conditions. They also examined the effects of garlic mustard on AM inoculum potential in the field. garlic mustard leachates prevented spore germination, inhibited the formation of AM associations with tomato plants and significantly reduced the germination of tomato seeds. They also reduced the root length

of tomato and sorghum seedlings, THeir results suggest that garlic mustard may reduce the competitive abilities of native plants by interfering with the formation of mycorrhizal associations and root growth.

Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of the Common Reed, Phragmites australis, into North America. Proceedings of the National Academy of Science 99: 2445-2449.

Cryptic invasions are a largely unrecognized type of biological invasion that lead to underestimation of the total numbers and impacts of invaders because of the difficulty in detecting them. The distribution and abundance of Phragmites australis in North America has increased dramatically over the past 150 years. This research tests the hypothesis that a non-native strain of Phragmites is responsible for the observed spread. Two noncoding chloroplast DNA regions were sequenced for samples collected worldwide, throughout the range of Phragmites. Modern North American populations were compared with historical ones from herbarium collections. Results indicate that an introduction has occurred, and the introduced type has displaced native types as well as expanded to regions previously not known to have Phragmites. Native types apparently have disappeared from New England and, while still present, may be threatened in other parts of North America.

Sanders, I. R. (2002). “Ecology and Evolution of Multigenomic Arbuscular Mycorrhizal Fungi.” The American Naturalist 2002 160:s4, S128-S141

Arbuscular mycorrhizal fungi (AMF) form extremely important mutualistic symbioses with most plants. Their role in nutrient acquisition, plant community structure, plant diversity, and ecosystem productivity and function has been demonstrated in recent years. New findings on the genetics and biology of AMF also give us a new picture of how these fungi exist in ecosystems. In this article, I bring together some recent findings that indicate that AMF have evolved to contain multiple genomes, that they connect plants together by a hyphal network, and that these different genomes may potentially move around in this network. These findings show the need for more intensive studies on AMF population biology and genetics in order to understand how they have evolved with plants, to better understand their ecological role, and for applying AMF in environmental management programs and in agriculture. A number of key features of AMF population biology have been identified for future studies and most of these concern the need to understand drift, selection, and genetic exchange in multigenomic organisms, a task that has not previously presented itself to evolutionary biologists.

Sheley, R. L., J. S. Jacobs, and M. F. Carpinelli. 1998. Distribution, biology, and management of diffuse knapweed (Centaurea diffusa) and spotted knapweed (Centaurea maculosa). Weed Technol. 12:353–362.

Diffuse knapweed, a biennial or short-lived perennial, and spotted knapweed, a perennial, are taprooted Eurasian weeds invading rangeland in the western United States and Canada. Knapweed (Centaurea spp.) invasion is associated with reductions in biodiversity, wildlife, and livestock forage, and increased erosion. Spotted knapweed grows to about 1 m and usually has purple flowers, whereas diffuse knapweed is slightly shorter, usually with white flowers. Persistent flower bracts on diffuse knapweed bear a rigid terminal spine about 8 mm long with four or five pairs of shorter lateral spines. Bracts on spotted knapweed have dark spotted tips. Knapweed management involves a combination of containing infestations and control efforts. Hand pulling in areas with small infestations can be effective for controlling spotted and diffuse knapweeds. Picloram applied at 0.28 kg ha-’ provides control for about 3 yr. Effective long-term control of knapweeds requires periodic applications of picloram, which are only cost effective on highly productive range sites with a residual grass understory. About 12 insect species have been released for knapweed biocontrol. Seed production has been reduced by 46% by insects feeding in the flower heads. Although insects have not reduced spotted knapweed densities, they may

stress the weed and shift the competitive balance to associated species. Sheep grazing reduces the density of very young seedlings and may limit seedling recruitment into the population. In areas without a residual understory of desired plant species, revegetation of knapweed-infested rangeland is required. Components of any integrated weed management program are sustained effort, constant evaluation, and the adoption of improved strategies.

Stinson KA, Campbell SA, Powell JR, Wolfe BE, Callaway RM, et al. (2006) Invasive plant suppresses the growth of native tree seedlings by disrupting belowground mutualisms. PLoS Biol 4(5): e140. DOI: 10.1371/journal.pbio.0040140

The impact of exotic species on native organisms is widely acknowledged, but poorly understood. Very few studies have empirically investigated how invading plants may alter delicate ecological interactions among resident species in the invaded range. We present novel evidence that antifungal phytochemistry of the invasive plant, Alliaria petiolata, a European invader of North American forests, suppresses native plant growth by disrupting mutualistic associations between native canopy tree seedlings and belowground arbuscular mycorrhizal fungi. Our results elucidate an indirect mechanism by which invasive plants can impact native flora, and may help explain how this plant successfully invades relatively undisturbed forest habitat.

Talmage, E, and E. Kiviat (2002, revised 2004). Japanese Knotweed and Water Quality on the Batavia Kill in Greene County, New York: Background Information and Literature Review". Hudsonia Ltd.: Report to Greene County Soil and Water Conservation District and New York City Department of Environmental Protection. Annandale, NY.

Tewksbury, L., Casagrande, R., Blossey, B., Häfliger, P., and Schwarzländer, M., 2002. Potential for Biological Control of Phragmites australis in North America. Biological Control, 23:191-212.

Phragmites australis is a cosmopolitan plant that is undergoing a population explosion in freshwater and tidal wetlands on the east coast of North America. Literature and field surveys reveal that of the 26 herbivores currently known to feed on P. australis in North America (many accidentally introduced during the last decade), only 5 are native. In Europe, over 170 herbivore species have been reported feeding on P. australis, some causing significant damage. Of these herbivores, rhizome-feeding species with considerable negative impact on P. australis performance include the lepidopterans Rhizedra lutosa (already present in North America), Phragmataecia castaneae, Chilo phragmitella, and Schoenobius gigantella. Stem-boring moths in the genera Archanara and Arenostola and the chloropid fly Platycephala planifrons can have large detrimental impacts on P. australis in Europe and should be evaluated for their potential as biological control agents. In addition, the interaction of potential control agents with accidentally introduced P. australis herbivores needs to be evaluated in North America. Regardless of the results of the genetic analyses, any decision to introduce additional host-specific herbivores in an attempt to control P. australis will require considerable dialogue. This decision needs to weigh the current negative ecological and economic impacts of P. australis and the benefits and risks of a biological control program.

Thompson, M. J. 1996. Winter foraging response of elk to spotted knapweed removal. Northwest Sci. 70:10–19.

Picloram was used to convert 110 ha of an historically cultivated grassland (thereafter old-field) from spotted knapweed (Centaurea maculosa) to grass on an elk winter range in western Montana. About 30 ha were left untreated. Elk walked in adjacent knapweed and grass stands indiscriminately, but foraged almost exclusively in the grass stand.

Trammell, M. A. and J. L. Butler. 1995. Effects of exotic plants on native ungulate use of habitat. J. Wildl. Manage. 59:808–816.

Leafy spurge (Euphorbia esula), smooth brome (Bromus inermis), Japanese brome (B. japonicus), and downy brome (B. tectorum) are exotic plant species that dominate and displace native forage species throughout much of central North America. However, information on how exotic plant infestations affect native ungulate use of habitat is limited. We used pellet-group densities to estimate use of habitat by bison (Bos bison), elk (Cervus elaphus), and deer (Odocoileus spp.) during 1992-93 growing seasons within 4 exotic plant-infested and 4 comparable noninfested grassland habitats in Theodore Roosevelt National Park, North Dakota. We used twig count and twig measurement methods to estimate use of browse during summer (1992) and winter (1992-93), respectively, for both leafy spurge-infested and noninfested woodland habitats. Bison use of 2 leafy spurge-infested grassland habitats averaged 83% less than that for noninfested sites ($P < 0.001$). Deer pellet-group densities, normally highest within creeping juniper (Juniperus horizontalis)-little bluestem (Schizachyrium scoparium) habitat, were reduced <70% by infestations of leafy spurge (1992, $P = 0.035$; 1993, $P = 0.002$). Use of bromegrass-infested grassland by bison, elk, and deer was similar to that for noninfested sites for 1992 and 1993 ($P > 0.05$). Use of browse in green ash (Fraxinus pennsylvanica) chokecherry (Prunus virginiana) habitat during summer and winter was reduced an average of 32% by infestations of leafy spurge ($P < 0.05$). The reduction in native ungulate use of leafy spurge-infested sites may be attributed to lower forage production in infested sites as well as simple avoidance.

Tulbure, M.G., Johnston, C.A., and Auger, D. L., 2007. Rapid Invasion of a Great Lakes Coastal Wetland by Non-native Phragmites australis and Typha. Journal of Great Lakes Research 33(sp3):269-279.

Great Lakes coastal wetlands are subject to water level fluctuations that promote the maintenance of coastal wetlands. Point au Sauble, a Green Bay coastal wetland, was an open water lagoon as of 1999, but became entirely vegetated as Lake Michigan experienced a prolonged period of below-average water levels. Repeat visits in 2001 and 2004 documented a dramatic change in emergent wetland vegetation communities. In 2001 non-native Phragmites and Typha were present but their cover was sparse; in 2004 half of the transect was covered by a 3 m tall, invasive Phragmites and non-native Typha community. Percent similarity between plant species present in 2001 versus 2004 was approximately 19% (Jaccard's coefficient), indicating dramatic changes in species composition that took place in only 3 years. The height of the dominant herbaceous plants and coverage by invasive species were significantly higher in 2004 than they were in 2001. However, floristic quality index and coefficient of conservatism were greater in 2004 than 2001. Cover by plant litter did not differ between 2001 and 2004. The prolonged period of below-average water levels between 1999 and early 2004 exposed unvegetated lagoon bottoms as mud flats, which provided substrate for new plant colonization and created conditions conducive to colonization by invasive taxa. PCR/RFLP analysis revealed that Phragmites from Point au Sauble belongs to the more aggressive, introduced genotype. It displaces native vegetation and is tolerant of a wide range of water depth. Therefore it may disrupt the natural cycles of vegetation replacement that occur under native plant communities in healthy Great Lakes coastal wetlands.

U.S. EPA (Environmental Protection Agency). (2008) Predicting future introductions of nonindigenous species to the Great Lakes. National Center for Environmental Assessment, Washington, DC; EPA/600/R-08/066F. Available from the National Technical Information Service, Springfield, VA, and http://www.epa.gov/ncea.

The Great Lakes of the United States have been subjected to adverse ecological and economic impacts from nonindigenous species (NIS). Ballast water from commercial shipping is the major means by which NIS have entered the Great Lakes. To help resource managers assess the future arrival and spread of invasive species, 58 species were initially identified as having a moderate or high potential to spread and cause ecological impacts to the Great Lakes. Using a species distribution model (the Genetic Algorithm for Rule-Set Production or GARP), areas within the Great Lakes where 14 of these 58 potential invasive species could find suitable habitat, were identified. Based on the model and species depth tolerances, all of Lake Erie and the shallow water areas of the other four Great Lakes are most vulnerable to invasion by the 14 modeled species. Analysis of ballast water discharge data of vessels entering the Great Lakes via the St. Lawrence Seaway revealed that the original source of most ballast water discharges came from Canada and Western Europe. The Great Lakes ports at greatest risk for invasion by the 14 modeled species from ballast water discharges are Toledo, Ashtabula and Sandusky, OH; Gary, IN; Duluth, MN; Milwaukee and Superior, WI; and Chicago, IL. Since early detection is critical in managing for NIS, these results should help focus monitoring activities on particular species at the most vulnerable Great Lakes ports. This assessment demonstrates that successful invasions are best predicted by knowing the propagule pressure (i.e., the number of larvae/individuals entering a new area) and habitat matching (i.e., how similar is the invaded area to the native range of the species).

Ward, Edward. 1942. Phragmites management. Transactions, 7th North American Wildlife Conference. 7: 294-298. [14959].

Wells, A.W.; Nieder, W.C.; Swift, B.L.; O'Connor, K.A., and Weiss, C.A., 2008. Temporal changes in the breeding bird community at four Hudson River tidal marshes. Journal of Coastal Research, SI(55), 221–235.

In 1986 and 1987, the New York State Department of Environmental Conservation and the Hudson River Foundation sponsored a study of avian breeding habitats in six tidal marshes on the Hudson River Estuary. Local concern prompted a repeat of this study at Iona Island Marsh in 2004 and at four of the marshes in 2005 (Iona Island Marsh, Constitution Marsh, Tivoli North Bay, and Stockport Flats). This study had three main objectives: (1) to document bird species breeding in these four marshes, (2) to determine how the marsh-breeding populations have changed since the 1986–87 study, and (3) to relate the spatial distribution of marsh-nesting species to measurable habitat variables within marshes. A total of 3522 observations of birds, representing 83 species, were recorded from April 28, 2005, to June 30, 2005. These observations were made by sampling 109 fixed observation stations five times using both visual and vocalization sampling methods. Nineteen of those species are dependent on emergent marsh habitats. The most common marsh-dependent species encountered during this study were Red-winged Blackbird (Agelaius phoeniceus) and Marsh Wren (Cistothorus palustris). These two species each accounted for 23–47% of the marsh-dependent guild at Constitution Marsh, Tivoli North Bay, and Stockport Marsh. Marsh Wrens were nearly absent from Iona Island Marsh (_1.0%); there, Red-winged Blackbirds accounted for more than 77% of the marsh bird community. Red-winged Blackbirds also dominated the marsh avian communities at Constitution and Stockport Marshes. Bird species diversity decreased significantly since 1986–87 at Iona Island and Constitution Marshes. Decreased diversity corresponds with an increase in the density of Red-winged Blackbirds. At Iona Island Marsh, this shift in the avian community to almost entirely Red-winged Blackbirds coincided with a shift of the plant community dominance from narrowleaf cattail (Typha angustifolia) in 1986–87 to common reed (Phragmites australis) in 2004–05. This shift was not evident at Constitution Marsh, Tivoli North Bay, or Stockport Marsh, although the number of Phragmites australis has also expanded at these sites. In addition to our survey, we found a total of 230 nests in 2005. Major findings of the bird nest searches were (1) the very low density of nests found at Iona Island Marsh (five nests total in 2004 and

2005), (2) the most common nest encountered at the other three marshes was that of the Marsh Wren (83% of total nests observed), and (3) the highest bird nest density occurred at Tivoli North Bay (65 nests ha_1).

Wilcox, K.L., S.A. Petrie, L.A. Maynard, and S.W. Meyer, 2003. Historical distribution and abundance of Phragmites australis at Long Point, Lake Erie, Ontario. Journal of Great Lakes Research, 29(4):664-680.

Recent expansion of Phragmites australis throughout many Great Lakes wetlands has caused concern among resource managers because it is thought to degrade waterfowl habitat and reduce biodiversity. Wetlands at Long Point, Lake Erie, have some of the most important habitats for staging waterfowl on the Great Lakes and anecdotal evidence suggests that Phragmites has been expanding rapidly in some of these wetlands. To make informed management decisions, a better understanding of historical changes in distribution and abundance of this species is needed, as well as the ability to identify which plant species/communities Phragmites is replacing. Long Point's wetland communities were digitally mapped from aerial photographs from 1945 to 1999. The aerial extent of Phragmites stands was measured by digitizing vegetation boundaries, ground-truthing, and analyzing the data using a GIS. A geometric growth formula was used to determine the intrinsic rate of change of Phragmites over time.

Phragmites abundance fluctuated throughout the period (1945: 4 ha; 1955: 7.7 ha; 1964: 69 ha; 1968: 3.6 ha; 1972: 15.1 ha; 1978: 17.7 ha; 1985: < 4 ha; 1995: 18 ha; 1999: 137 ha), but its abundance increased exponentially between 1995 and 1999 (137 ha; intrinsic rate of growth in area = +0.50/yr). The species/communities that were most often replaced by Phragmites between 1995 and 1999 were Typha spp. (33.8%), marsh meadow (31%), sedge/grass hummock (10.8%), and other mixed emergents (9.6%). Of 31 stands analyzed within the study area, 28 (90%) were of a non-native strain of Phragmites australis (haplotype M) that has been rapidly expanding throughout the Atlantic region of the United States. We suggest that the recent rapid expansion of Phragmites at Long Point is the direct result of this exotic invasion, and that it has been facilitated by both declines in Great Lakes water levels and increases in ambient air temperatures; anthropogenic and natural disturbances have possibly also contributed. Given the invasive nature of the exotic genotype, combined with future global warming predictions, Phragmites probably will continue to rapidly expand throughout lower Great Lakes coastal wetlands.

Wolfe, B.E., Rodgers, V.L., Stinson, K. A., and Pringle, A., 2008. The invasive plant Alliaria petiolata (garlic mustard) inhibits ectomycorrhizal fungi in its introduced range. Journal of Ecology 96(4): 777–783.

1. Ectomycorrhizal (EM) fungi play key roles in forest ecosystems, but the potential effects of invasive plants on EM fungal communities have not been assessed. In this study, we tested whether the non-mycorrhizal herbaceous plant Alliaria petiolata (garlic mustard) can alter the abundance of EM fungal communities in North America.

2. In three forests in New England, USA, we compared EM root tip abundance in soils where A. petiolata had invaded to adjacent areas without a history of A. petiolata invasion. At one site, we also intensively sampled EM root tip abundance across the edges of A. petiolata patches to determine the spatial pattern of A. petiolata effects on EM fungi. In a glasshouse experiment, we experimentally invaded soils with A. petiolata and Impatiens capensis , a native species and compared EM fungal colonization of white pine (Pinus strobes) seedlings grown in both soils. We also measured the effect of the A. petiolata allelochemical benzyl isothiocyanate on the growth of three species of EM fungi in pure culture.

3. In the field, EM fungal root tip biomass was lower in invaded soils, with the strongest reductions observed in forests dominated by conifers. Alliaria petiolata invasion did not have a significant effect on total root biomass.

The influence of A. petiolata on EM fungal abundance in the field was localized, with the strongest inhibition observed within 10 cm of the edge of A. petiolata patches.

4. Pine seedlings growing in soils that were experimentally invaded with A. petiolata also had lower EM fungal root tip biomass compared to uninvaded soils. The native species I. capensis caused similar reductions in EM fungal colonization. Growth of pure cultures of all three species of EM fungi was completely inhibited by benzyl isothiocyanate.

5. Synthesis. Alliaria petiolata inhibits the growth of EM fungi in forests of its introduced range. Changes in EM fungal communities caused by the invasion of A. petiolata may influence tree seedling establishment and biogeochemical cycling.

Appendix E. Key to Page Invasive Species Photos

Page	Scientific name	Common name	Photographer
---	*Centaurea maculosa*	spotted knapweed	MNFI
i-ii	*Euphorbia esula*	leafy spurge	Norman Rees, USDA Agricultural Research Station
iii	*Phragmites australis*	*Phragmites*	John M. Randall, The Nature Conservancy
iv-v	*Alliaria petiolata*	garlic mustard	MNFI
1	*Vincetoxicum rossicum*	pale swallow-wort	MNFI
2-3	*Elaeagnus umbellata*	autumn olive	MNFI
4-5	*Lythrum salicaria*	purple loosestrife	MNFI
6-7	*Berberis thunbergii*	Japanese barberry	MNFI
8-9	*Rhamnus cathartica*	common buckthorn	MNFI
10-11	*Polygonum cuspidatum*	Japanese knotweed	MNFI
12-13	*Hydrocharis morsus-ranae*	European frogbit	MNFI
14-15	*Lonicera tatarica*	Tatarian honeysuckle	Chris Evans, The University of Georgia
16-17	*Lonicera maackii*	Amur honeysuckle	MNFI
18-19	*Pastinaca sativa*	Wild parsnip	MNFI
20-21	*Lonicera japonica*	Japanese honeysuckle	MNFI
22-23	*Centaurea maculosa*	spotted knapweed	MNFI
24-25	*Butomus umbellata*	flowering rush	MNFI
26-27	*Celastrus orbiculatus*	Oriental bittersweet	MNFI
28-29	*Rhamnus frangula*	glossy buckthorn	MNFI
30-31	*Multiflora rose*	multiflora rose	MNFI
32-33	*Pinus sylvestris*	Scotch pine	MNFI
34-35	*Rhodotypos scandens*	black jetbead	MNFI
36-77	*Euphorbia esula*	leafy spurge	Norman Rees, USDA Agricultural Research Station